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USAAEFA PROJECT NO. 80-07

CLIMATIC LABORATORY SURVEY
HUGHES YAH-64 HELICOPTER

FINAL REPORT

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MARCH 1982

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER USAAEFA PROJECT NO. 80-07	2. GOVT ACCESSION NO. AD-A124 670	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CLIMATIC LABORATORY SURVEY HUGHES YAH-64 HELICOPTER		5. TYPE OF REPORT & PERIOD COVERED FINAL, 2 NOV-16 DEC 1981
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) GARY L. BENDER CHARLES F. ADAM RICHARD T. SAVAGE		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US ARMY AVN ENGINEERING FLIGHT ACTIVITY EDWARDS AIR FORCE BASE, CA 93523		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 46-2-P2029-01-46-EC
11. CONTROLLING OFFICE NAME AND ADDRESS US ARMY AVN RESEARCH & DEVELOPMENT COMMAND 4300 GOODFELLOW BOULEVARD ST. LOUIS, MO 63120		12. REPORT DATE MARCH 1981 82 13. NUMBER OF PAGES 260
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Environmental Testing	YAH-64 Helicopter
Climatic Laboratory	125, 70, -25, and -50°F
Nine Deficiencies	Twenty-two Shortcomings

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Environmental testing of the YAH-64 helicopter was conducted in the McKinley Climatic Laboratory, Eglin Air Force Base, Florida. The US Army Aviation Engineering Flight Activity was responsible for the evaluation of aircraft systems and the US Army Aviation Development Test Activity was responsible for the mission equipment evaluation. The test consisted of 14.4 hours of aircraft operating time between 2 November and 16 December 1981. Testing was accomplished at 125, 70, -25, and -50°F with the aircraft attached to the

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hangar floor. At each temperature, testing consisted of preflight inspections, APU and engine starts, simulated mission profiles, engine shut down, and maintenance inspections. Nine deficiencies were found which would preclude mission accomplishment: 1) the fire control computer was unreliable, 2) the symbol generator required an excessive warm-up time at cold temperatures, 3) the heading and attitude reference system was unreliable, 4) the environmental control unit failed to provide adequate heating or cooling to the cockpit and avionics bays at -25°F, -50°F, and 125°F, 5) the TADS/PNVS and weapons systems did not function adequately at 125°F, 6) the APU aborted its start sequence because it could not accelerate the accessory gearbox to operating speed at -25°F and -50°F, 7) the hydraulic hand pump was ineffective at -25°F and -50°F, 8) the utility hydraulic manifold allowed the accumulator to bleed off at -25°F and -50°F, and 9) failure of the hydraulic flex lines at cold ambient temperatures. In addition to these deficiencies, 22 shortcomings were found. A production AH-64 should be tested in the climatic laboratory with solar radiation on the cockpit and with the crew wearing chemical/biological clothing and masks.

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SUBJECT: Directorate for Development and Qualification Position on the Final Report of USAAEFA Project No. 80-07, Climatic Laboratory Survey, Hughes YAH-64 Helicopter

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1. The purpose of this letter is to establish the Directorate for Development and Qualification position on the subject report. The evaluation was conducted using a prototype YAH-64 at the US Air Force Climatic Laboratory, Eglin AFB, FL. The objective of the survey was to verify that the helicopter systems, subsystems, and components could function satisfactorily from +125°F to -25°F and with the addition of winterization kits, from +125°F to -50°F. The Hughes Helicopters, Inc., System Specification for the AH-64A Advanced Attack Helicopter, AMC-SS-AAH-H10000A details the specific environmental operating ranges of the individual systems and components.

2. This Directorate agrees with the report findings, conclusions and recommendations with the following exceptions and additional comments provided. Comments are directed to the report paragraphs as indicated.

a. Paragraph 28. A production configuration battery was not used in this test. The production design will incorporate a heater integral to the battery. This battery will be able to furnish the energy required for operating the emergency bus at ambient temperatures down to -65°F. It will not be necessary to remove the battery from the aircraft except for routine maintenance purposes. A quick release mechanism is not justified.

b. Paragraph 30. A concept which would permit the crewchief to energize the AC busses from outside the aircraft is judged to be a safety hazard. Aircraft systems should not be capable of being energized without a crewman "manning" the controls. An automatic switchover mechanism between external and internal power is not warranted. Inadvertent APU shut down can be avoided without the expense and weight of an automatic switchover circuit.

c. Paragraph 53. The center strap of the five point restraint system is designed to maintain the side restraint straps positioned low on the torso to prevent "submarining" of the crew below the restraint system. Providing an adjustment in the center strap would compromise the basic design and functioning of the five-point restraint system. Although some inconvenience may be experienced by not so trim aviators, the safety/crashworthiness aspects are far more important.

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d. Paragraph 61a. Failure of the APU to accelerate the accessory gearbox at -25°F and -50°F is a deficiency and fails to comply with the requirements of Paragraph 3.7.5.8.1 of the System Specification. The preceding deficiency is a specification noncompliance because the specification requires that the engine starting system be capable of starting both engines at -25°F without a winterization kit and at -65°F with a winterization kit. This specification noncompliance should be included under Paragraph 63 of the USAAEFA test report. An improved clutch engagement switch is expected to eliminate this problem in production.

e. Paragraph 61b. Failure of the environmental control unit to provide adequate heating and cooling to the cockpits and avionics bays at -25°F, -50°F and +125°F is a specification noncompliance item. Paragraphs 3.7.15.5.1, 3.7.15.5.2, and 3.7.15.5.3 of the System Specification define the requirements for heating, cockpit cooling, and electronic avionics cooling. Paragraph 3.7.15.5.1 requires crew station temperatures of not less than +40°F for outside ambient temperatures down to -65°F. During testing at -25°F temperatures at the pilot's head and foot level were below freezing, and in the case of the CPG did not exceed 32°F one hour after start of testing. Paragraph 3.7.15.5.2 of the System Specification requires that cockpit temperatures do not exceed 85°F for the case of 120°F ambient temperatures. Cockpit temperatures as high as 104°F were measured during testing. Paragraph 3.7.15.5.3 of the System Specification requires that cooling air delivery temperatures not exceed 85°F. Delivery temperatures as high as 100°F were measured during testing. Design changes to the environmental control system are expected to eliminate these problems in production.

f. Paragraph 61c. This problem was traced to mechanical operation of the emergency hydraulic valve. Although a wiring change was made, accumulator pressure bleed-off was still observed. Inability of the utility manifold to prevent pressure loss from the accumulator at -25°F and -50°F is a deficiency.

g. Paragraph 61d. Hydraulic hand pump problems were traced to a foreign object (chip) which wedged at the piston periphery and caused binding. Since the hydraulic hand pump failure was an isolated type failure, it is not considered a deficiency.

h. Paragraph 61e. Failure analysis of one failed hydraulic hose indicated that the hose was manufactured with a tube compound that is more susceptible to stress cracking than compounds now in use. The other two hoses could not be located for failure analysis. Production hoses will be manufactured with a more stress crack resistant tube.

i. Paragraph 62a. Canopy defog performance does not comply with the requirements of Paragraph 3.7.15.1.1 of the System Specification. The specification requires that the defog system must maintain the canopy transparent area surface temperature above the surrounding air dew point temperature. During -25°F testing, the defog system provided only limited visibility through the side panels. During -50°F testing, a canopy area of

only 2 inches wide and 10 inches long could be adequately defogged. This specification noncompliance should also be listed under Paragraph 63 of the USAAEFA report. A redesign of defog ducts and a change in duct material are expected to eliminate this problem in production.

j. Paragraph 62b. DASE disengagement at -25°F is attributed to a HARS malfunction at the same temperature. Corrective action lies in redesign to improve HARS operation at colder temperatures.

k. Paragraph 62c. Failure of the engine condition lever detents to engage at -25°F and -50°F has been traced to the use of an improper lubricant. Proper lubrication is expected to eliminate this problem.

l. Paragraph 62d. Stiffness of engine condition levers at cold temperatures is also expected to be eliminated by use of the proper lubrication.

m. Paragraph 62e. See Paragraph 53.

n. Paragraph 62f. The procedural problem will be eliminated in production by a change which will provide a direct wiring connection from the utility outlet to the emergency bus.

o. Paragraph 62g. Difficult operation of the engine cowling and canopy latcher will be eliminated by calling out improved cleaning and lubricating procedures.

p. Paragraph 70. Failure of the battery to start the APU at temperatures of -25°F and below is a specification noncompliance item, per paragraph 3.7.5.8.1 of the System Specification, and should be corrected in production. It should not be necessary to remove the battery when temperatures are below freezing.

q. Paragraph 71. A battery quick release mechanism is not required if the low temperature problem is corrected in production.

3. Based upon the preceding, helicopter operation is unacceptable at -50°F and marginally acceptable at -25°F due to the identified deficiencies and related noncompliance to the System Specification. Based on the deficiencies and System Specification requirements, the YAH-64 did not demonstrate the capability to operate acceptably at temperatures below -25°F. Additional climatic laboratory retesting is required to evaluate corrections to deficiencies identified during the USAAEFA tests to insure compliance to System Specification requirements below -25°F.

FOR THE COMMANDER:

CHARLES C. CRAWFORD, JR.
Director of Development
and Qualification

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INTRODUCTION

BACKGROUND

1. In June 1973, the United States Army Aviation Systems Command awarded a Phase 1 Advanced Development Contract to Hughes Helicopters Internatinal (HHI). The contract required HHI to design, develop, fabricate, and initiate a development/qualification effort on two AAH prototypes and a ground test vehicle as part of Government Competitive Test (GCT). In December 1976, the US Army Aviation Research and Development Command (AVRADCOM) awarded a Phase 2 Engineering Development Contract to HHI for further development and qualification of the YAH-64 to include full system, subsystems and qualification of mission essential equipment. A part of the Phase 2 qualification effort is the requirement for a Climatic Laboratory Survey of the YAH-64. AVRADCOM requested (ref 1, app A) the US Army Aviation Engineering Flight Activity (USAAEFA) to conduct the Climatic Laboratory Survey with the support of the US Army Aviation Development Test Activity (AVNDTA).

TEST OBJECTIVE

2. The objective of the Climatic Laboratory Survey was to verify that the helicopter systems, subsystems, and components can function satisfactorily from +125°F to -25°F and with the addition of winterization kits, from +125°F to -50°F.

DESCRIPTION

3. The YAH-64 is a two-place, tandem-seat, twin-engine helicopter with four-bladed main and antitorque rotors and conventional wheel landing gear. The helicopter is powered by two General Electric T-700-GE-700R turboshaft engines, and has a moveable horizontal stabilator. A 30mm gun is mounted on a turret assembly on the underside of the fuselage below the front cockpit. The helicopter has wings with four stores pylons for carrying HELLFIRE missiles or 2.75-inch folding fin aerial rockets. Modification of the aircraft for the climatic tests included removal of the tail wheel and horizontal stabilator, installation of a weight to simulate the inertial characteristics of the stabilator, installation of three support fixtures and a tail boom tie down structure, and installation of exhaust ducting and a data system. A winterization kit was installed for tests at -50°F. The kit consisted of a second nitrogen bottle added to the utility hydraulic accumulator system which doubled the volume of nitrogen in that system. Photos 1 through 6 show the aircraft as installed in the hangar. Further description of the test helicopter may be found in appendix B.

Photo 1. Left Front View

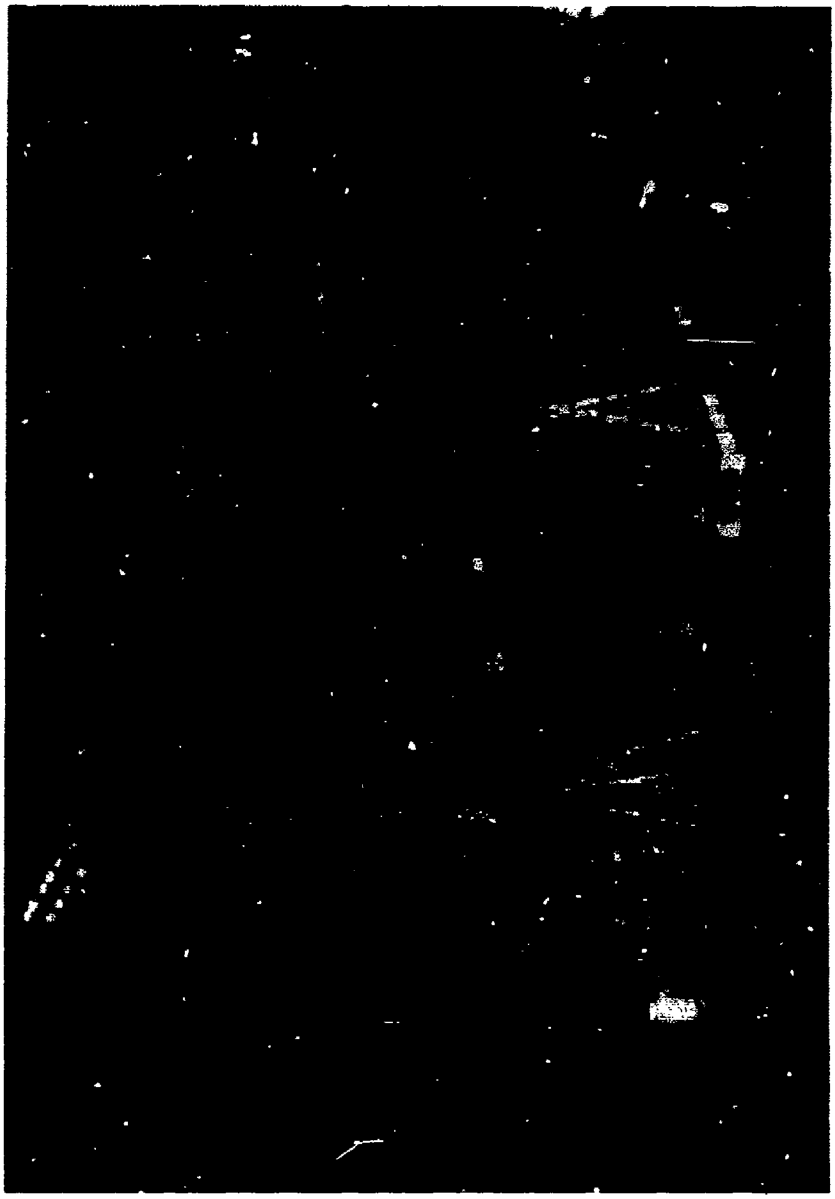


Photo 2. Right Side View

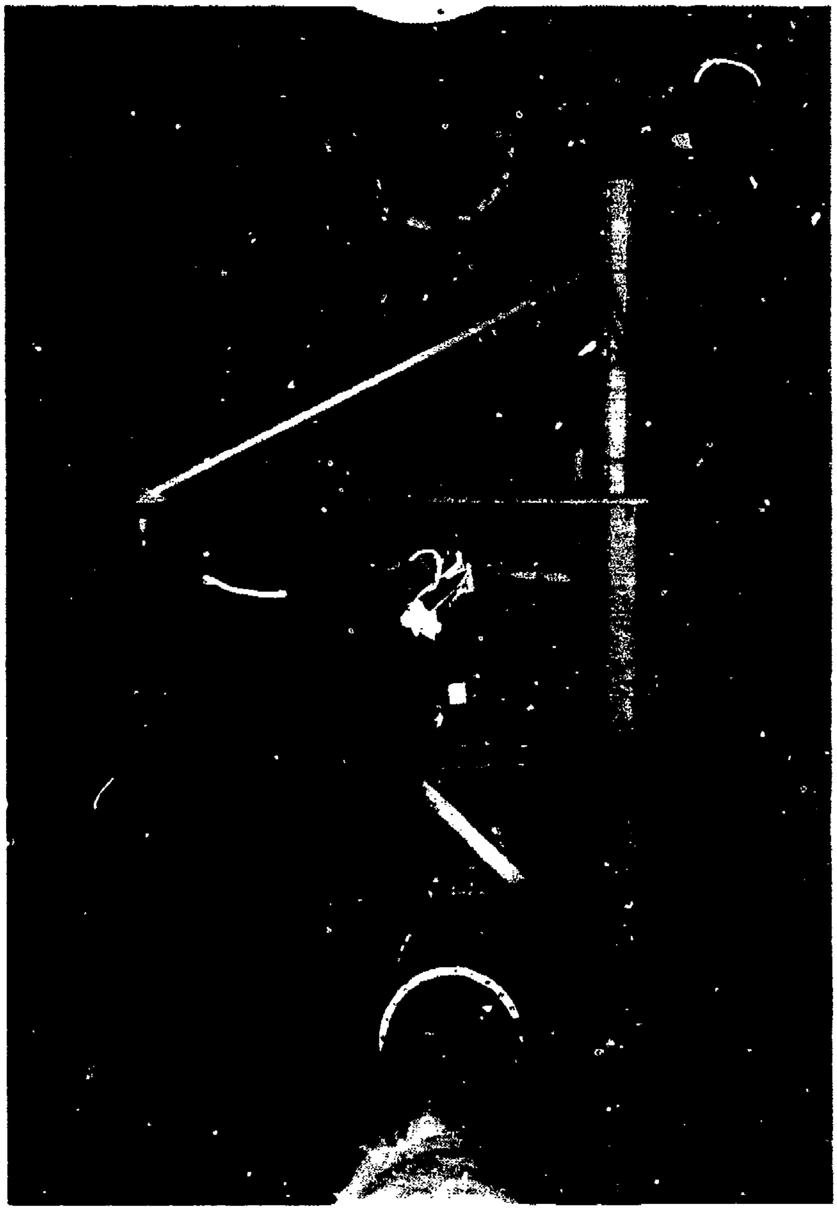


Photo 3. Rear View

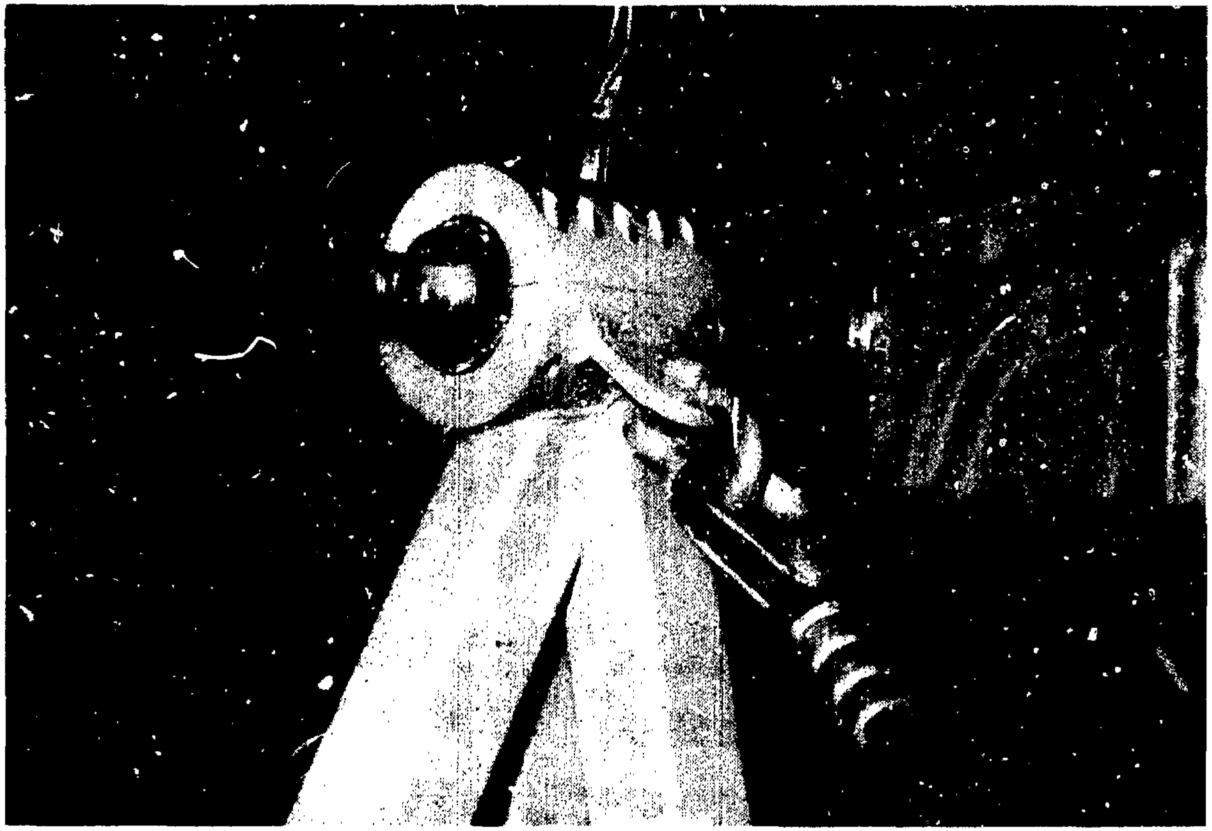


Photo 4. Left Front Tie-down Attaching Point

Photo 5. Mid Tail Boom Tie-down

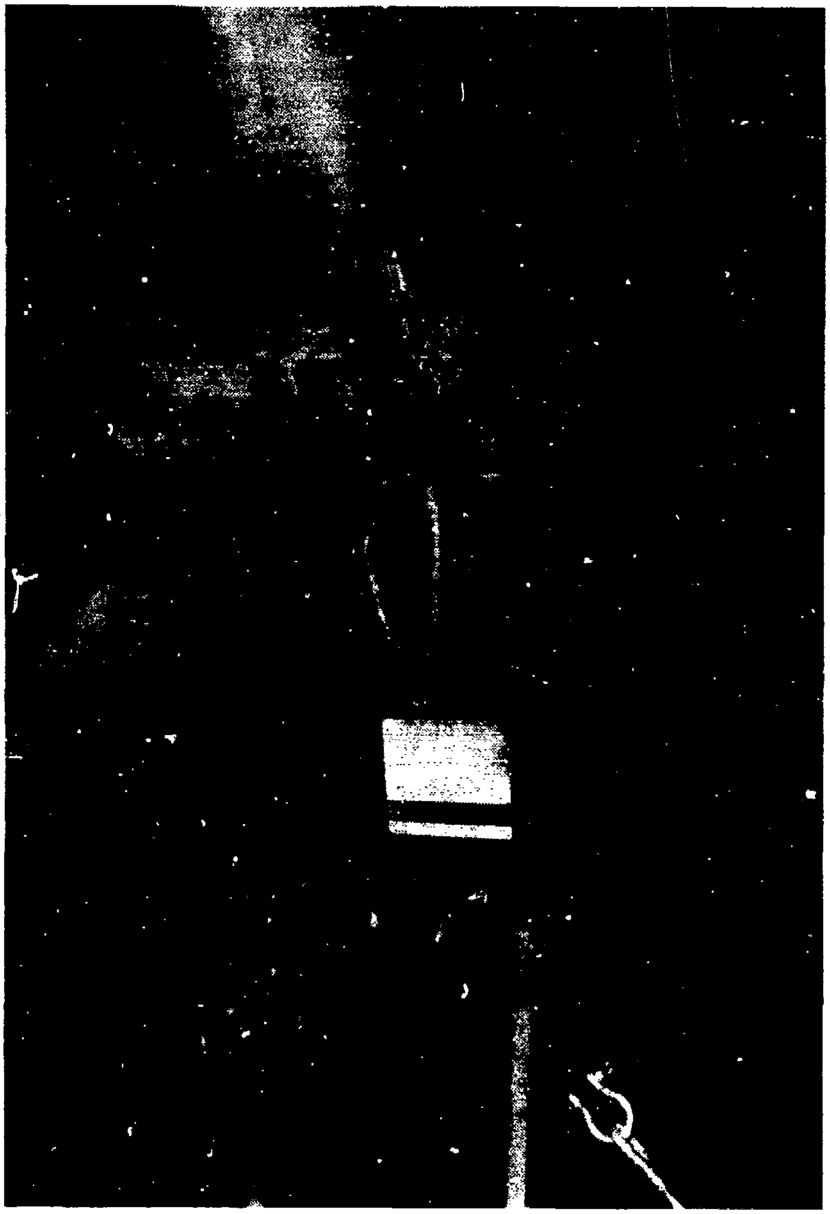


Photo 6. Aft Tie-down

TEST SCOPE

4. Environmental testing of the YAH-64 helicopter was conducted in the McKinley Climatic Laboratory, Eglin AFB, Florida, by USAAEFA with the support of the Armament Division (AD), AVNDTA, and HHI. The test consisted of 14.4 hours of aircraft operating time during a 6-week time span and was conducted in accordance with the USAAEFA test plan (ref 2, app A). Testing was accomplished at temperatures of 125, 70, -25, and -50°F. The actual sequence of test temperatures is shown in table 1. The type fuel, lubricating oil and hydraulic fluid used at each temperature is also shown in table 1. The aircraft was attached to the hangar floor to allow the helicopter to develop thrust to engine intermediate power. At each temperature, testing consisted of preflight inspections, APU and engine starts, simulated mission profiles, engine shut down, and daily maintenance inspections. The aircraft was operated in accordance with the limits of the operator's manual, as modified by the special operating instructions issued by AVRADCOM (ref 3). The AVNDTA was responsible for evaluating mission equipment. The results of that evaluation are contained in appendix H.

TEST METHODOLOGY

5. The YAH-64 was exposed to a stabilized temperature environment for a long enough period of time to ensure that all aircraft components and fluids had reached that temperature before initiating a test run. Prior to each run, the hydraulic hand pump operation was evaluated, a preflight inspection was accomplished and all aircraft fluid levels were recorded. The auxiliary power unit (APU) and main engines were then started and the mission equipment was powered up using procedures in the published checklist (ref 4, app A) as modified by the cold weather supplement (ref 5). All aircraft systems were checked for proper functioning during a simulated mission flight profile. The aircraft and systems were then shut down per the checklist and a postflight inspection was conducted (including the recording of all fluid levels). The test card used is presented in appendix D and incorporates both the checklist items and the functional checks. Data were recorded on magnetic tape or hand recorded from cockpit gages.

Table 1. Test Scope

Temperature[1]	Fuel	OIL	HYDRAULIC FLUID
70°F (21°C) -25°F (-32°C)	JP5	MIL-L-23699C	MIL-H-83282A
-50°F (-46°C) +125°F (52°C) 70°F (21°C) +125°F (52°C) -25°F (-32°C) 0°F (-18°C)[2]	JP4	MIL-L-7808H	MIL-H-5606H

[1]The sequence of test conditions is from top to bottom in this table.
[2]APU start only.

RESULTS AND DISCUSSION

GENERAL

6. The results presented here concern only the air vehicle evaluation.The mission equipment evaluation is presented in appendix H. Five deficiencies attributable to temperature were found which would preclude mission accomplishment: 1) the APU aborted its start sequence because it could not accelerate the accessory gearbox to operating speed at -25°F and -50°F; 2) failure of the Environment Control Unit (ENCU) to provide adequate heating or cooling to the cockpit and avionics bays at -25°F, -50°F, and +125°F; 3) the utility hydraulic manifold allows the accumulator pressure to bleed off, 4) the hydraulic hand pump is ineffective at -25°F and -50°F; and 5) the failure of hydraulic flex lines at -25°F and -50°F. In addition to these deficiencies 11 shortcomings were found 9 of which were probably caused by temperature.

AUXILIARY POWER UNIT

7. The auxiliary power unit (APU) was started by a hydraulic starter motor which was driven by the utility hydraulic accumulator. The APU was started at all temperatures prior to main engine starts, (accessory gear box (AGB) not turning), and at the end of test runs, prior to shutting down the main engines (AGB turning) (figures 1 through 12, app E). The APU never failed to start when the accumulator nitrogen precharge and total pressure were correct.At the first 70°F and -25°F test conditions and at 125°F and 0°F the APU started and attained full operating speed on every attempt with the AGB not turning (figs 1, 2, 7, and 8, app E). Every start attempt was successful at all temperatures with the AGB already turning.

8. On the first start attempt at -50°F the APU-to-AGB clutch failed (fig 5, app E). The APU achieved operating speed, but could not turn the accessory gearbox. A new clutch was installed and several more start attempts were made. The APU started on each attempt and accelerated to clutch engagement (approximately 60 percent speed). When the clutch engaged, the APU speed decreased to zero and the start sequence was aborted by the APU control unit (fig 6, App E). No problems were encountered at the subsequent 70°F nor +125°F test conditions.

9. A second -25°F test condition was added to the planned tests primarily to evaluate APU starts with the new clutch installed. Start attempts with the AGB not turning resulted in the APU

starting and accelerating to clutch engagement then decelerating to zero (fig 3, app E). Prior to this second -25°F test, the lubricating oil and hydraulic fluid had been changed to MIL-L-7808H and MIL-H-5606H, respectively.

10. A manual switch was then installed at -25°F to allow engagement of the clutch at 90 percent speed rather than 60. One start attempt was made and the APU and AGB achieved operating speed (fig 4, app E). This switch was a test item and not part of the standard YAH-64 configuration.

11. Normal field operations require that the APU be started to drive the AGB which provides hydraulic, electrical, and pneumatic power for main engine starts and systems operation. Failure of the APU to accelerate the AGB to operating speed will preclude mission accomplishment and is therefore a deficiency.

ENGINES

12. The YAH-64 is powered by two YT700-GE-700R turboshaft engines. They are started by air turbine starters which are driven by air from the pressurized air system (PAS). During this test, engines were started with PAS pressurized by an external air cart and by the shaft driven compressor on the AGB. At each temperature, engine restarts were accomplished one minute and two minutes after engine shutdown. The start procedure was to initiate the start sequence with the engine condition lever (ECL) in the OFF position, then advance the PAL to IDLE at the first indication of gas generator speed. Representative time histories of engine starts and warmups are shown in figures 13 through 33 app E. Additionally, left engine temperature characteristics are presented in figures 34 through 37.

13. No engine related problems were encountered at 70°F. At the first -25°F test condition, the left engine failed to start on one attempt because the fuel boost pump did not come on during the automatic start sequence as it should have (fig. 16, app E). This problem could not be duplicated and is not considered temperature related. Also during the first -25°F condition, a right engine start had to be aborted because starter disengegement speed (48%) had not been reached prior to the 90 second ignitor limit.The engine had achieved ignition, was accelerating, and had exhaust gas temperature within limits. With a longer ignitor

time limit, the start would have been successful. The current limit is to protect the ignitors. The limit should be reevaluated for cold weather operations to extend the start time limit if ignition has been achieved and the engine is accelerating.

14. At -50°F the first several left engine start attempts were unsuccessful (fig 17 app E). The cold weather start procedure which requires cycling the ECL was used during these attempts. Fuel flow to the engine during these attempts was 3 to 4 gallons per hour. Fuel flow during successful starts was 9 to 12 gallons per hour. The engine hydromechanical unit was replaced and subsequent starts were successful.

15. At -25°F and -50°F both engine PAL's were stiff and difficult to operate. This stiffness would make engine control during ECU lock out operations difficult and is a shortcoming. At the same temperatures the mechanical detents on the pilot's ECLs failed to operate. This could allow inadvertent shut down or overspeed of an engine when the detent failed to work. Failure of the PAL detents at -25°F and -50°F is a shortcoming.

16. Current cold weather engine start and warmup procedures call for starting one engine, warming it up at idle for five minutes, accelerating it to 100% power turbine speed (N_p) and then repeating the process for the second engine. Using this procedure, a minimum of 12 minutes is required to get both engines operating at 100% N_p.The engine start procedures should be reevaluated to shorten this time. Consideration should be given to changing the procedure to starting the second engine with the first still at idle and advancing each engine to 100% N_p as soon as the engine oil pressure decreases to the normal operating range.

17. Engine oil pressures exceeded the 120 psi maximum steady state limit during engine start/warmup at -25°F and -50°F (figures 16 through 18, 23 and 24 appendix E). The pressures dropped below 100 psi (i.e. into the normal operating range) prior to the end of the required engine idle warmup time. At +125°F, the left engine oil pressure at idle was 26 psi, which illuminated the engine oil pressure caution lights. When the engine was accelerated, the light extinguished.

CABIN AIR TEMPERATURE SURVEY

18. The environmental control system (ECS) operation and performance were evaluated at all test temperatures. The environmental control unit (ENCU), located on the left side of the transmission deck provided conditioned air to the crew compartments and

avionics bays. The air was distributed through ducts on the right and left side of the cabin floor. Air entered the cockpit through controllable vents on the instrument panels and floor level openings in the distribution duct. For all tests the copilot/gunner's (CPG) floor outlets and all the instrument panel outlets were open. The pilot's floor outlets were closed by HHI and defined as a possible production configuration. The canopy was closed before the environment control unit (ENCU) was turned ON. A variable temperature control, located on the ECS panel, regulated the output temperature of the ENCU. At 70°F the variable temperature selector was set on maximum cold except for 8 minutes when the selector was set on maximum hot for comparison (fig. 38, app E). During tests conducted below 70°F the temperature selector was left in the maximum hot position, while at the 125°F test condition the selector was set at the maximum cold position. The flight crew wore one-piece nomex flight suits and leather boots for the 70°F and 125°F tests. Heavy winter parkas, pants and rubber air barrier boots were worn for the cold temperature tests. The crewmember's hands were protected during all tests with nomex flight gloves. No evaluations of the ECS were made with the crew wearing chemical/biological protective clothing or gas masks. Additional cooling and heating in the cockpits will be necessary for the crew to perform missions at temperature extremes. Future tests of a production AH-64 should be conducted with solar radiation on the cockpit, as detailed in the specification requirement, and with the crew wearing chemical/biological clothing and masks to insure the ECS could provide adequately conditioned air to the cabin. Data gathered during this test are presented in figures 38 through 45, appendix E and are summarized in table 2.

19. The applicable requirements of the systems specification for performance of the ECS (ref 6, app A), are summarized below:

a. Cockpit heating requirements are specified in paragraph 3.7.15.5 (ref 6). A crewstation temperature not less than +40°F must be provided for outside air temperatures down to -65°F, and the temperature difference between the head and foot levels of either crewmember must be less than 10°F. These requirements must be met within one minute after takeoff, and on the ground at idle rpm within five minutes of engine start with the canopy closed.

b. Cockpit cooling requirements are specified in paragraph 3.7.15.5.2 (ref 6). The cabin air temperature must not exceed 85°F for ambient outside air temperatures up to 120°F.

Table 2. Summary of Cabin Temperature Survey

TARGET TEST TEMPERATURE °F (°C)	MAXIMUM ENCU OUTLET °F (°C)	TEMPERATURE °F (°C)											
		ECL[1] FLY + 5 MIN						TAKEOFF[2] + 1 MIN					
		PILOT			CPG			PILOT			CPG		
		Head	Waist	Foot	Head	Waist	Foot	Head	Waist	Foot	Head	Waist	Foot
70 (21)	167 (75) Hot[3] 35 (2) Cold[4]	93 (34) Hot	86 (30) Hot	72 (22) Hot	79 (26) Hot	82 (28) Hot	79 (26) Hot	68 (20) Cold	68 (20) Cold	68 (20) Cold	68 (20) Cold	68 (20) Cold	68 (20) Cold
-25 (-32)	158[3] (70)	70 (21)	82 (28)	54 (12)	68 (20)	68 (20)	68 (20)	64 (18)	77 (25)	25 (-4)	68 (20)	68 (20)	61 (16)
-50 (-45)	167[3] (75)	14 (-10)	32 (0)	-26 (-32)	-2 (-19)	12 (-11)	12 (-11)	23 (-5)	32 (0)	-13 (-25)	17 (-8)	23 (-5)	23 (-5)
125 (51)	59[4] (15)	90 (32)	93 (34)	116 (47)	107 (42)	104 (40)	100 (38)	104 (40)	95 (35)	122 (50)	104 (40)	104 (40)	104 (4)

NOTES:

[1]Engine condition levers at FLY, N_R = 100%.
[2]Takeoff power, 60% at -50°F, 70% at 125°F.
[3]Temperature selector set on maximum hot.
[4]Temperature selector set on maximum cold.

c. Avionics cooling requirements are specified in paragraph 3.7.15.5.3 (ref 6). Because the forward avionics bay (FABS) and the target acquisition and designation system/pilot night vision system (TADS/PNVS) turret are cooled using cockpit air, this paragraph restates the minimum and maximum temperatures allowed for cockpit air (+40°F and +85°F, respectively). The aft avionics bay can be supplied with ambient air at temperatures from -65°F to +120°F.

d. Ambient limits and operating conditions under which the above requirements must be met are specified in paragraph 3.7.15.5.4 (ref 6). This paragraph allows for ground and flight operations, canopy closed, at outside air temperatures from -65°F to +120°F. Solar radiation and air humidity were also specified but were not simulated during this test.

20. The ENCU was evaluated first at 70°F (21°C) to determine the maximum cooling and heating capacity of the system. The variable temperature selector was set to the maximum cold position and the ENCU produced an outlet temperature of 35°F (2°C), (fig. 38, app E). After 15 minutes of APU operation cockpit temperature had dropped a maximum of 9°F (5°C) from the ambient test temperature of 70°F. The temperature selector was then set to the maximum hot position and the ENCU outlet temperature stabilized at 167°F (75°C) in less than 2 minutes. The cockpit temperatures increased a maximum of 25°F (14°C) above the 70°F test temperature in 8 minutes.There was no loss of air temperature in the ECS ducting from the ENCU outlet to the pilot's floor outlet. However, between the pilot and CPG outlets, the air temperature dropped approximately 54°F (30°C) with the temperature selector set to maximum hot. Temperature differences between the head, waist, and foot levels were insignificant in both cockpits except at the hot ECS setting. At that setting, the aft cockpit, foot-level temperature was approximately 14°F (8°C) below the head and waist levels. The temperatures to the TADS and FABS remained essentially unchanged at either temperature setting (fig. 42, app E).

21. The heating operation of the ECS was tested at -25°F (-32°C) and data are presented in figures 39 and 43, appendix E. The ENCU outlet temperature averaged 149°F (65°C) during the test with insignificant duct losses between the ENCU and the pilot station. Between the pilot and CPG outlet, however, the conditioned air temperature dropped by 45°F (25°C). The time to reach the required minimum temperature of 40°F (4°C) at the pilot station was 4 minutes at the waist, 8 minutes at the head, and 28 minutes at the feet. The temperature at the pilot's feet was below freezing for nearly half of the 2 hour mission. The pilot's feet and hands were very uncomfortable during this test. The temperature at the

cyclic grip was 32°F (0°C) as measured with hand-held instrumentation. The waist-level temperature presented in figure 39 (which averaged approximately 70°F) was measured near the left edge of the pilot's seat and had ECS air blowing directly on the sensor. The difference between the pilot head and foot level temperatures averaged 14°F (8°C) and was a maximum of 22°F (12°C). This large temperature gradient was caused mainly by cold ambient air entering the cockpit through the 30 mm weapon turret and holes in the floor around the pedals. Table 3 presents speeds of air blowing up through the holes in the floor as measured with hand-held instrumentation in the aft cockpit. At high power settings, the air speeds increased and produced wind chill effects which added to crew discomfort. The pilot's lower duct outlets being closed also contributed to the temperature difference. The temperatures at the CPG station and at the TAD/PNVS and FABS inlets reached the minimum temperature of 40°F (4°C) in 10 minutes. Temperatures in the CPG cockpit were acceptably uniform during the test.

Table 3. Pilot Station Air Speed[1]

	PILOT'S FLOOR	PEDALS LEVEL	CYCLIC GRIP	INSTRUMENT PANEL DUCT	
	Left	Right		Left	Right
APU ONLY	0.5	0.5	0	68[2]	68[3]
100% rotor RPM collective down	3	4	0.5		
50% Torque	11	10	1		
100% Torque	17	22	1		

NOTES:

[1]Speed in miles per hour
[2]Speed measured 8 inches away from the outlet
[3]Speed measured 10 inches away from the outlet

22. The ECS heating performance was evaluated during -50°F tests and data are presented in figures 40 and 44 of appendix E. The ENCU outlet temperature started at 122°F (50°C) and reached a maximum of 167°F (75°C) 35 minutes after engine start, the same maximum temperature produced during 70°F tests. Air temperature at the pilots ECS outlet was approximately 10°F less than at the ENCU outlet. The maximum temperature loss in the ducting between the pilot's floor vent and the CPG's vent was 45°F (25°C). The CPG's right hand vent temperature increased from 32°F (0°C) shortly after turning on the ENCU to 91°F (33°C) one hour after engine start. The temperatures at both crew stations were below freezing for the first 35 minutes of the test and air entering the cockpit from the instrument panel vents cooled rapidly and produced a wind chill factor of 14°F around the upper body of both crew members. During the first 5 minutes of operation the wind chill was below -30°F. The vents were directed away from the body and both crew members wore heavy wool scarves over the nose and mouth. Even with this additional protection the CPG suffered cold injuries to his face during the 1.5 hour test. The temperature variation between the pilot's feet and upper body was always more than 36°F (20°C) with a maximum foot temperature of 0°F (-18°C) one hour into the test. The wind chill around the pilot's feet and lower legs was -40°F at 50% torque settings and -58°F during simulated climbs at 100% torque. The temperature at the cyclic grip during a climb, 100% torque, was 19°F. Operation of cockpit switches, instruments, and controls require the use of the light weight nomex flight glove. However, this glove will not protect crewmembers hands from frostbite without adequate cabin heat. During this test, the pilot blocked the controls with his legs and feet, locked the collective with the friction adjustment and placed his gloved hands in artic mitters between data points to prevent damage to his hands. Temperatures around the copilot's head were 15°F cooler than the lower body. Cold air leaked into the CPG's cockpit from around the canopy seal and circulated around the CPG's head. The time to reach the minimum temperature of 40°F (4°C) required by the specification was 35 minutes in both cockpits. The pilot's feet and the CPG's head did not reach the minimum temperature during the test. The TADS and FABS inlet reached the minimum temperature of 40°F(4°C) fifty minutes after engine start.

23. The cooling capacity of the ECS was evaluated at 125°F ambient temperatures. The ENCU outlet temperature stabilized at 60°F (15°C) after engine start and increased to 68°F (20°C) during simulated climb and cruise flight (fig. 41, app E). The temperatures at both crew stations were from 95°F (35°C) to 104°F (40°C) throughout the test, and the difference between the pilots head and feet reached 18°F during the test. The ENCU air

was blown directly on the crew members but would not have a cooling effect when wearing body armor to protect the upper body area. The TADS and FABS inlet temperatures averaged 104°F (40°C) during the test. Ambient air is circulated through the aft avionics bay for cooling and then vented overboard. Temperatures recorded at the inlet to the exhaust fan averaged 131°F (55°C) and peaked at 138°F (59°C).

24. The ECS failed to provide adequately conditioned air to the cockpits or avionics except at 70°F. At -25°F the ECS failed to keep the pilot's feet and hands above freezing during simulated flight profiles. During tests conducted at -50°F the cockpit and TADS/FABS temperatures were below freezing up to one hour after start of the ENCU. The cooling capacity of the ECS was limited at 125°F, lowering the cockpit and TADS temperatures a maximum of 35°F from ambient conditions. Many electronic components of the mission equipment failed due to high temperature during this test (see Appendix H). Crew fatigue in a high work load environment will occur within the first few minutes at extreme temperatures without properly conditioned air in the cockpit. The failure of the ECS to provide adequately conditioned air to the crew stations and avionics bays at -25°F, -50°F and 125°F is a deficiency.

25. The ECS failed to meet the minimum heating requirement of 40°F detailed in paragraph 3.7.15.1 (ref 6, app A) in that the temperature at the pilot's feet was 31°F one minute after takeoff at -25°F ambient and tha the temperature at both crew stations was -4°F five minutes after engine start at -50°F ambient. Also, the maximum specified temperature variation of 10°F between the head and foot level was exceeded by more than 22°F at the pilot's station at -25°F and -50°F, and at the copilot's station by 15°F at -50°F ambient temperatures. The ECS failed to meet the cooling requirement of paragraph 3.7.1 .5.2 during the 125°F tests in that the maximum allowed temperature of 85°F was exceeded by 10°F to 19°F. The requirements for air conditioning at the FABS and TADS/PNVS inlets specified in paragraph 3.7.15.5.3 were also not met. At -50°F the inlet temperatures did not reach the 40°F minimum temperature until one hour into the test run. At 125°F the inlet temperatures exceeded the 85°F maximum allowable throughout the test run. Table 4 presents a specification compliance summary.

26. The canopy defog system was evaluated at -25° and -50°F. The system mixed PAS air with cabin air and ducted it on to the four canopy side panels. The canopy nozzle temperatures were recorded in the pilots station after a -25°F test, with rotors stopped. The temperature differential from the

Table 4. Specification Compliance of Cabin and TADS/FABS Temperature Survey

TARGET TEST TEMP °F (°C)	ECL[2] FLY + 5 MIN					TAKEOFF[3] + 1 MIN				
	PILOT		CPG		TADS/FABS	PILOT		CPG		TADS/FABS
	Min Temp	Head/Foot Difference	Min Temp	Head/Foot Difference	Min Temp	Min Temp	Head/Foot Difference	Min Temp	Head/Foot	Min Temp
70(21)	S	S	S	S	S	S	S	S	S	S
-25(-32)	S	U (Foot)	S	S	S	U (Foot)	U	S	S	S
-50(-45)	U	U	U	U	U	U	U	U	U	U
125(51)	U	U	U	S	U	U	U	U	S	U

NOTES:

[1]S = Satisfactorily met specification requirements, U = Failed to meet the specification requirement.
[2]Engine condition levers at FLY, N_R = 100%
[3]Takeoff power, 60% at -50°F at 125°F.

back to the front of the nozzle was no more than 2°C on either duct. The outlet temperatures were also recorded during a single engine descent at 70% torque and 25°F ambient conditions. The left duct outlet was 7°C and the right -4°C. The side panels were slow to defog and only provided limited visibility. During the -50°F test the defog system cleared a canopy area approximately 2 inches wide and 10 inches long. The inadequate canopy defog operations at -25° and -50°F is a shortcoming.

ELECTRICAL SYSTEMS

27. An evaluation of the electrical system was conducted throughout the temperature range tested. The battery was a non-production item and the battery heater identified in the system specifications (ref 6, app A) was not available for this test. Additionally, the generators and transformer/rectifiers were prototype configuration and not scheduled for production. Data for tests at 70°F, -25°F, -50°F, and 125°F are presented in figures 46 through 49, appendix E.

28. The battery functioned properly at 70°F and 125°F, however, a cold soaked battery failed to power the emergency bus at tests conducted at -25°F and -50°F. Two tests were conducted with a fully charged cold soaked battery with unsatisfactory results. The battery would dimly light the caution lights for one minute until the voltage dropped below 18 volts. The battery should be removed from the aircraft and stored in a warm environment to preserve the charge when ambient conditions are expected to be below 0°F. The present method of securing the battery does not facilitate quick installation or removal. Four bolts and safety wire are required to hold the battery in position. A quick release system should be installed to secure the battery.

29. The DC emergency system, consisting of the charger and battery interface, functioned properly at 70°F, -25°F, and -50°F. At 125°F (51°C) ambient temperature the HOT BAT caution light, part of the battery charging protection system, illuminated intermittently. The charger was designed to stop charging when the battery temperature exceeded 122°F (50°C $\pm$3°) and illuminate the HOT BAT caution light when the battery reached 135°F (57 $\pm$3°C). The battery and charger are located in the aft avionics bay. Temperatures recorded at the inlet to the exhaust fan averaged 135°F (57°C) and peaked at 138°F (59°C) 85 minutes after APU start (fig. 45, app E). The charger failed to charge the battery 22 minutes after APU start at 125°F ambient

temperature and the voltage dropped to 24 volts, battery potential for the rest of the test (fig. 49, app E). The failure of the DC charging system at 125°F is a shortcoming.

30. The power transfer from the ship's system to external power was not automatic. The transfer could only be executed if the BAT/OFF/EXT PWR switch was placed in the EXT PWR position and the EXT PWR reset button was pressed as the last generator was turned off. Failure to follow this procedure interrupted electrical power to the APU control unit which caused the APU to shut down. In the case where external power is applied to the ship at the external recepticle and all systems are off, the crew chief should be able to energize the AC busses with a reset button at the external recepticle. An automatic feature should also be incorporated which would automatically switch to external power whenever ship's power was not within acceptable ranges of frequency and voltage. The system should switch back to ship's power when those frequency and voltage conditions are met. Such a system would eliminate the need for an EXT PWR position and reset button on the power panel, and preclude inadvertent APU shutdowns. The power transfer between the ship's system and external power as presently designed is a shortcoming.

FUEL SYSTEM

31. At each temperature, the fuel crossfeed valve, boost pump, transfer pump and refuel valve were checked for proper operation. Additionally, gravity and pressure refueling were accomplished. The pneumatic boost pump (located in the aft tank) comes on automatically during engine starts and may be turned on using a switch in the cockpit at any other time. Both modes of operation were checked. During one left engine start at -25°F the boost pump failed to operate. That problem could not be repeated and was the only problem encountered with any of the fuel system components.

FLIGHT CONTROLS

32. The main and tail rotor flight controls consist of mechanical linkages from the cockpit pedals, cyclic stick and collective stick to irreversable hydraulic actuators which control the blade pitch through mechanical links. The hydraulic actuators have integral stability augmentation system (SAS) actuators which are controlled electrically by the digital automatic stabilization equipment (DASE) computer. The DASE makes control inputs to augment pilot control inputs and to oppose aircraft rates. The

cyclic and pedal controls incorporate a magnetic brake force feel system. The stabilator is controlled by two electronic stabilator control units which drive 2 electromechanical actuators. Above a threshold speed of approximately 30 knots the stabilator angle is controlled as a function of airspeed and collective control positions.

33. The cyclic, collective, and pedal controls appeared to function well throughout the test. During one run at -50°F the cyclic and pedal controls were initially ratchety but the movement became smooth after a short period of time. The trim/force feel system functioned properly and high forces were not apparent at any temperature. Hydraulic actuator frequency responses could not be evaluated because of insufficient time in the schedule to install the necessary test hardware. Future climatic tests should place priority on actuator frequency response evaluations.

34. Special operating constraints for the climatic laboratory did not allow DASE operation while the rotors were turning. Because the APU would not turn the AGB at -50°F until after the rotors were turning, the DASE could not be evaluated at that temperature. At -25°F the roll and yaw channels of the DASE disengaged whenever the pilot made a small control movement. At 70°F and 125°F the DASE functioned normally. DASE disengagement at -25°F is a shortcoming. Future climatic tests should allow DASE operation with rotors turning to ensure a complete evaluation of this system.

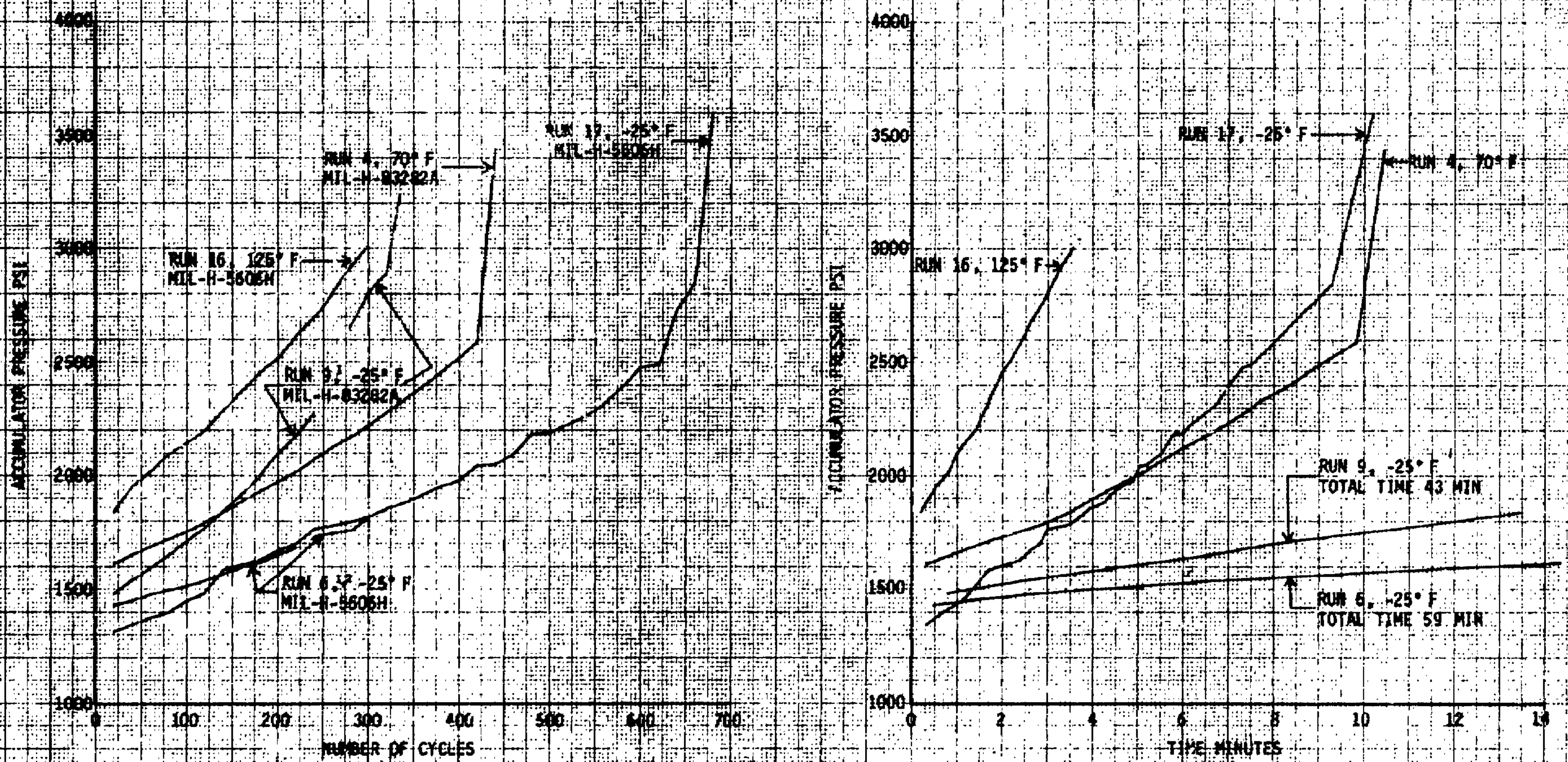
35. Full travel of the stabilator actuators was checked using the manual mode. Operation of the automatic mode was checked by pushing the reset button with the stabilator at one extreme of its travel and checking to see that the stabilator returned to 25 degrees leading edge up. The stabilator functioned properly at all conditions except the first run at +125°F. During that run, the stabilator would move through its full range in the manual mode. However, when the reset button was pushed, the stabilator moved to 19 degrees leading edge up (rather than 25 degrees) and the STAB FAIL caution light illuminated. This test was repeated several times on this run with the same results. During the run, the stabilator should remain at 25 degrees, leading edge up, because the airspeed remains at zero. During this +125°F run, however, the stabilator moved up and down as a function of collective position.Both stabilator control units were changed after this run and the stabilator functioned properly for the remaining runs (including another +125°F test condition).

HYDRAULIC SYSTEMS

36. The YAH-64 hydraulic system consists of a primary flight control system and a utility system which powers the flight controls, weapons systems, rotor brake and the APU start motor through the utility accumulator. A description of the aircraft hydraulic system is contained in appendix B and in the operator's manual. The hydraulic system was inspected prior to each run and monitored during the run to identify any leaks or system malfunctions. The system was serviced with MIL-H-83282A fire-resistant hydraulic fluid for the first two test temperatures (70°F and -25°F) and with MIL-H-5606H for all other tests. Hydraulic system data are presented in figures 50 through 61, appendix E.

37. The utility hydraulic hand pump was evaluated for efficiency and ease of operation. Fluid was supplied to the pump under pressure from the utility manifold reservoir. Each test was started by depleting the accumulator hydraulic pressure, reading and servicing the nitrogen precharge if necessary, and pressurizing the accumulator with the hand pump. The pump, when serviced with either fluid, operated satisfactorily at 70° and 125°F requiring from 3.5 to 10 minutes and 300 to 460 strokes to pressurize the system to 3000 pounds per square inch (psi). Resistance was encountered throughout the full travel of the stroke and increased the pressure in the accumulator from 3.5 to 4.1 psi per stroke. The pump was less effective at -25°F tests with MIL-H-83282A fluid. It was necessary to allow from 10 to 15 seconds between strokes to fill the pump cylinder to produce a full stroke. Midway through the charging cycle the pump cylinder would not fill and pressure dropped from 4.5 to less than 1 psi increase per stoke. Pressurized air was applied to the utility manifold reservoir through the pressurized air system (PAS) air inlet check valve. The pump then functioned properly to complete the charge cycle. On another occasion, this procedure was used but the pump would not begin to work. Figure 1 shows the number of strokes required to charge the accumulator. A new utility manifold was installed and a second test conducted at -25°F using MIL-H-5606H fluid. The pump charged the accumulator to 3000 psi in 10 minutes averaging 2.4 psi per stroke. There was a reduced efficiency of 32% (an increase of 220 strokes to achieve the same pressure in the same time) compared to the 70°F tests. The pump operation at -50°F with MIL-H-5606H fluid was unsatisfactory. An increase to 30 to 40 seconds between strokes was required to allow the pump cylinder to fill with fluid and less than 50% of the pump handle travel produced any pressure increase.

FIGURE 1
UTILITY HYDRAULIC ACCUMULATOR AND HAND PUMP EFFICIENCY
YAH-64 USA S/N 74-22249



[1]EXTERNAL AIR APPLIED TO UTILITY MANIFOLD RESERVOIR TO PRESSURIZE HYDRAULIC RETURN SYSTEM.
[2]PRESSURIZATION OF UTILITY ACCUMULATOR WITH HAND PUMP ABORTED, ENGINE START ACCOMPLISHED WITH EXTERNAL PNEUMATIC STARTING UNIT.

Further evaluations of the pump at this temperature were terminated and the accumulator charged using an external hydraulic power cart. The inadequate hand pump operations at -25°F with MIL-H-83282A and at -50°F with MIL-H5606H is a deficiency.

38. The utility hydraulic manifold incorporates the fluid reservoir and the emergency hydraulic system. Each of these components produced failures that were related to cold temperatures. The manifold, serviced with MIL-H-83282A, depleted the reservoir fluid through the low pressure relief valve. This occurred during the second test at a temperature of -25°F. The utility pressure fluctuated after APU START and the test was terminated 25 minutes later when the oil low light illuminated. The manifold was replaced and serviced with MIL-H-5606H fluid for the remaining tests. The emergency hydraulic system in the manifold provides accumulator pressure to the flight controls if the utility pressure system fails. A switch in the pilots station electrically energizes a solenoid on the manifold which hydromechanically activates valves in the manifold. The accumulator pressure is bled by activating the emergency hydraulic power switch and moving the flight controls. At all -25°F and -50°F temperatures, once activated, the system failed to close allowing accumulator pressure to bleed back to the reservoir. The solenoid valve was replaced after most tests and when checked at 70°F temperatures functioned properly. The manifold and "O" rings for the valve were also replaced, however, this did not correct the problem. The failure of the utility manifold to prevent pressure loss from the accumulator at -25°F and -50°F is a deficiency.

39. The utility hydraulic accumulator bled the nitrogen precharge into the hydraulic fluid during 70°F tests with MIL-H-83282A. The accumulator was replaced and operated satisfactorily at the -25°F tests. The -50°F tests were conducted with MIL-H-5606H fluid and a second nitrogen bottle connected to the system (winterization kit). The nitrogen precharge was increased from 1650 psi to the required 1850 psi for that ambient condition. Shortly after servicing the pressure had decreased and air was detected in the hydraulic fluid of the utility system. The system was bled and precharge reserviced to complete the test. Successive pre-run inspections during the next three tests at -50°F showed a decrease in precharge to approximately 1550, 1450 and finally 1100 psi. The failure of the utility accumulator system to hold a nitrogen precharge at -50°F with MIL-H-5606H is a shortcoming.

40. Flexible hydraulic lines failed and allowed loss of hydraulic fluid during cold temperature tests. Two pressure lines in the primary hydraulic system failed during the first test at -50°F

with MIL-H-5606H (photo 7). One line was attached to the pump output and the other located at the tailboom splice. The splice is peculiar to this prototype aircraft, and a flex line at this location is not planned for production. The third flex hose was located in the left wing stub, at the quick disconnect. This line failed during the last -25°F tests while the system was serviced with MIL-H5606H fluid. The failure of the flexible hydraulic pressure hoses at -25° and -50°F is a deficiency.

41. A second gas reservoir was installed to pressurize the utility accumulator for operations below -25°F. The duplicate bottle, the only winterization kit installed by HHI for this test, doubled the gas capacity to 305 cubic inches and was connected to the existing system after the -25°F test. After the last tests at -50° test the second gas bottle was disconnected by HHI prior to raising the hangar temperature to +125°F. The winterization kit should be able to operate from the lowest temperature in the detailed specification (-65°F) to at least 70°F without alteration. This would simulate operations in an artic climate where a cold aircraft may be moved into a heated hangar for maintenance and expected to operate. Further testing of the utility hydraulic accumulator system should be conducted, including the APU start motor and gas reservoir, with the winterization kit installed (second gas bottle) to insure proper system operation throughout the temperature range of -65°F to +125°F without modifications.

42. The accumulator pressure indicator on the ground service equipment panel is small and difficult to read accurately. The face of the indicator is approximately one and one sixteenth inch in diameter. Pressues cannot be read within 100 psi when 3/16 of an inch represents the pressure range of 1000 to 2000 psi. The nitrogen precharge varies linearly with temperature and requires pressure settings within 20 psi. The coarse scale and small size of the accumulator pressure indicator is inconsistent with the stated allowable precharge pressures and is a shortcoming.

43. The primary and utility hydraulic heat exchangers were evaluated at each test temperature and data are presented in figures 50 through 61. The exchangers were bypassed at 70°F. However, at -25°F and -50°F the fluids were cooled by 9 to 18°F (5°C to 10°). At 125°F the fluids into the coolers approached 212°F (100°C) with maximum temperature drop of less than 10°F (12°C). Only small control inputs were made at 5 minute intervals and the SAS links in the actuators were idle after the engine start. The utility system was thoroughly exercised at the end of each test run when the gun system was traversed throughout its

Photo 7. Hydraulic Flex Lines

azimuth and elevation limits. This limited test data indicates that the heat exchangers may not be needed. A further analysis of the hydraulic system data during hot day flight tests is recommended to confirm the need for heat exchangers.

ROTOR SYSTEMS

44. Special procedures are required to warm the main and tail rotor systems during cold weather operation, as published in a supplement to the operator's manual (ref 4 app A). The tail rotor teetering bearings are made of elastomeric material and required cycling the tail rotor in teeter prior to starting the engine. Each blade set had to be cycled one time within 5 minutes of engine start at -25°F and 5 to 10 times within 2 minutes of engine start at temperatures below -25°F. The bearings performed satisfactorily during all tests, however the warmup procedures may not be practical in the field environment. If wind exists during the preflight any warming of the bearings by teetering the tail rotors will be ineffective. In fact, the slow acceleration of the main rotor system during start at cold temperatures may provide the additional warming necessary beyond normal preflight checks. At - 50°F the main rotor system requires more than 2 minutes to start rotation after initiating the engine start sequence. The tail rotor bearing warmup procedures for cold weather operation should be reevaluated.

45. The cyclic control requires special procedures for cold weather operations. At temperatures of -44°F and below the cyclic must be moved forward two inches and held for 3 minutes at 100% N_R.This can only be completed after the 5 minute engine warmup at idle. The rotor system warmup procedures should be reevaluated, and if required to be accomplished, incorporated in conjunction with the engine runup procedures.

TRANSMISSIONS

46. The aircraft has 5 transmissions; the main transmission (a part of which is called the accessory gear box), 2 engines nose gearboxes, an intermediate gearbox in the tail rotor drive train, and the tail rotor gearbox. The engine nose gearbox on the YAH-64 each has a pump to deliver lubricating oil under pressure to the gears. The gearboxes have external cooling fins to prevent overtemperature, and therefore no oil cooler is incorporated. The only nose gearbox problem noted during the evaluation was excessive oil leakage at the output shaft seal and the oil filler caps.

47. The main transmission has two separate oil lubication systems (No. 1 (left) and No. 2 (right)). Each system consists of a sump, a pump, an oil cooler, and jets which spray oil on the gears. Oil sprayed on the gears can return to either sump. At -50°F the number 2 oil pump shaft failed and was not replaced until after the first +125°F run. The remaining oil system provided adequate lubrication and cooling at both -50°F and +125°F. This transmission was not in specification configuration in that the oil sumps were not isolated from one another and the float valves to prevent oil from returning to a sump having a very low oil level (e.g. leaking from battle damage) were not installed.

48. The accessory gearbox is actually the accessory drive section of the main transmission. The AGB has its own oil pump to draw oil from the main transmision number two oil sump and lubricate the accessory drive gears and the shaft-driven air compressor.The AGB oil system has no oil cooler. When the main transmission is turning, the AGB oil mixes with the main transmission oil and is cooled by the main transmission oil coolers. With the APU running and the main transmission not turning, the oil temperature in the AGB and main transmission rises rapidly (fig 62 through 66, app E). Prolonged APU operation at high ambient temperatures could result in transmission oil temperatures above the 140°C limit. Such prolonged APU runs might be required operationally to keep mission equipment such as the HARS and doppler in a ready status for fast reaction.

49. The intermediate and tail rotor gearboxes are sealed transmissions packed with a grease lubricant. No provisions for servicing are incorporated and no servicing should be required. The gearboxes functioned well throughout the test and the gearbox temperatures remained within limits. At the initial 70°F test condition, there was some evidence of grease seepage. The gearboxes were wiped clean and no further evidence of seepage was noted.

50. At -50°F the drive system accelerated very slowly when driven by just one engine at idle (as required by the current cold weather start procedures). Figure 28, appendix E shows that it took more than three minutes from initiation of the start sequence to get an indication of power turbine speed. More than eight minutes were required to reach idle speed. This slow main rotor acceleration could cause excessive main rotor flapping in high wind conditions. The cold weather engine start procedures should be reevaluated with an objective of speeding up the main rotor acceleration.

ANTI-ICE SYSTEMS

51. Anti-ice systems evaluated during this test were designed to protect the engines, the engine inlet fairings, the engine nose gearbox fairings, the cross shaft fairings, two windshield panels, and the TADS/PNVS components. The TADS/PNVS anti-ice systems evaluations are discussed in appendix H. These tests were not conducted in an icing environment and therefore the anti-ice capability could not be fully evaluated. All systems functioned properly in that they heated components they were designed to heat (fig 71 through 73, app E).

MISCELLANEOUS

52. During preflight inspections at -25°F and -50°F the engine cowling latches were very difficult to operate. Additionally, the canopy latches at -50°F were difficult to operate and on one run the pilot canopy latch could not be closed initially. Difficult operation of the engine cowling and canopy latches is a short coming.

53. The center strap of the five-point pilot restraint system is not adjustable. When the pilot wore artic clothing (at -25°F and -50°F) the release mechanism was located very low on the body and was covered by the outer jacket. During an emergency egress the release mechanism would be very difficult to reach. An adjustable center strap would allow positioning the mechanism higher on the body, making it more accessable. The lack of an adjustment on the restraint system center strap is a shortcoming.

54. Two caution/advisory lights functioned improperly during the test. The forward tank low fuel warning light illuminated at -50°F when the tank contained 760 pounds of fuel. The light should not illuminate until the tank has 210 $\pm$10 pounds or less, fuel remaining. During right engine starts on the last runs at +125°F and -25°F, the boost pump advisory light failed to illuminate although instrumentation confirmed that the pump was working. The light did illuminate during left engine starts during these runs. Improper operation of the low fuel warning and fuel boost pump advisory lights is a shortcoming.

CONCLUSIONS

GENERAL

55. The YAH-64 air vehicle did not function adequately at -25°F and -50°F.

SPECIFIC

56. Successful engine tests were accomplished at all temperatures using an external pneumatic power source or the APU.

57. The hydraulic flight control actuators did not leak fluid at any temperature.

58. The grease-packed intermediate and tail rotor gearboxes functioned properly at all temperatues.

59. The APU achieved ignition and accelerated at least until clutch engagement at all temperatures.

60. Main rotor acceleration is very slow at -50°F using current cold weather engine start procedures.

DEFICIENCIES

61 . The following deficiencies, which will preclude mission accomplishment, were found. The definition of deficiency as used in this report is presented in appendix D. They are listed in the order of relative importance.

a. The APU aborted its start sequences at -25°F and -50°F because it could not accelerate the accessory gearbox (para 11).

b. The environmental control unit failed to provide adequate heating or cooling to the cockpits and avionics bays at -25°F, -50°F, and +125°F (para 24).

c. The utility hydraulic manifold allowed accumulator pressure to bleed off at -25°F and -50°F (para 38)

d. The hydraulic hand pump is ineffective at -25°F and -50°F (para 37).

e. Flexible hydraulic pressure hoses failed at -25°F and -50°F (para 40).

SHORTCOMINGS

62. The following shortcomings were found and are listed in order of relative importance. The definition of shortcoming as used in this report is presented in appendix D.

a. Inadequate canopy defog at -25° and -50°F (para 26).

b. DASE disengagement at -25°F (para 34).

c. Failure of engine condition lever detents to engage at -25°F and -50°F (para 15).

d. Stiffness of engine condition levers at -25°F and -50°F (para 15).

e. Lack of adjustment on the restraint system center strap (para 53).

f. Poor procedure for external power to battery transfer (para 30)

g. Difficult operation of the engine cowling and canopy latches (para 52).

h. Improper operation of low fuel warning and fuel boost pump advisory lights (para 54).

i. Failure of utility hydraulic accumulator to hold a nitrogen precharge at -50°F (para 39).

j. Failure of the DC emergency system at 125°F (para 29).

k. The coarse scale and small size of the accumulator pressure indicator (para 42).

SPECIFICATION COMPLIANCE

63. The YAH-64 was found not to be in compliance with the following paragraphs of the Phase 2 Advanced Attack Helicopter Systems Specification, AMC-SS-AAH-H10000A (ref 6, app A). Additional specification noncompliance, beyond the scope of this evaluation, may exist.

a. Paragraph 3.7.15.5.1. At -25°F and -50°F cockpit temperatures failed to reach 40°F within 5 minutes with engines at idle or within one minute from takeoff. Also the temperature

difference between head and foot levels exceeded the 10°F maximum allowable in the aft cockpit at -25°F and -50°F and in the front cockpit at -50°F (para 26).

b. Paragraph 3.7.15.5.2. At 125°F the cockpit temperatures exceed the 85°F maximum allowable throughout the test run (para 26.).

c. Paragraph 3.7.15.5.3. The air temperature at the inlets to the FABS and TADS/PNVS exceeded the 85°F maximum allowable at 125°F, and failed to reach the minimum allowed temperature of 40°F until one hour into the run at -50°F (para 26).

RECOMMENDATIONS

64. The deficiencies listed in paragraph 61 should be corrected prior to production.

65. The shortcomings listed in paragraph 62 should be corrected.

66. A production AH-64 should be tested in the climatic laboratory to verify correction of the current deficiencies, and to validate the performance of subsystems and components which were not available for this test.

67. The time limit on ignitors during engine starts should be reevaluated for cold weather operations (para 13).

68. Engine start procedures for cold weather operations should be modified to provide faster main rotor acceleration and less engine warmup time (para 16).

69. Future climatic testing of this aircraft should be conducted with solar radiation on the cockpit and with the crew wearing chemical/biological clothing and masks (para 18).

70. The aircraft battery should be removed and stored in a warm environment when ambient temperatures are expected to be below freezing (para 28).

71. A quick release system should be installed to secure the battery (para 28).

72. Tail rotor bearing warmup procedures for cold weather should be reevaluated to decrease the number of cycles required and increase the allowable time between cycling and engine start (para 44).

73. The main rotor warmup procedure at -50°F should be reevaluated to reduce the overall time required from engine start to takeoff (para 45).

74. The utility hydraulic system with the winterization kit installed (second nitrogen bottle on accumulator) should be evaluated from +125°F to -65°F (para 41).

75. A further analysis of the hydraulic system data during hot day flight tests should be conducted to confirm the need for heat exchangers (para 43).

APPENDIX A. REFERENCES

1. Letter, AVRADCOM, DRDAV-DI, subject: *YAH-64 Climatic Laboratory Survey* 11 August 1981.

2. Test Plan, USAAEFA Project No. 80-07, *Climatic Laboratory Survey, Hughes YAH-64 Helicopter,* August 1981.

3. Letter, AVRADCOM, DRDAV-DI, subject: *YAH-64 Helicopter Climatic Hangar Operating Instructions,* 2 November 1981, revised 9 and 27 November 1981.

4. Draft Technical Manual, TM 55-1520-238-10, *Operator's Manual for Army YAH-64 Helicopter,* 1 May 1981.

5. Supplement to Draft Technical Manuals TM 55-1520-238-10 /10CL/23, *Cold Weather Supplement to YAH-64 Helicopter Operator and Maintenance Instruction Manuals,* 15 October 1981.

6. YAH-64 Phase 2 Advanced Attack Helicopter Specification, Hughes Helicopters, AMC-SS-AAH-H100000A, 10 December 1976.

APPENDIX B. AIRCRAFT DESCRIPTION

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GENERAL

1. The YAH-64 Advanced Attack Helicopter (fig. 1) is a tandem seat, two-place, twin turbine engine, single main rotor aircraft manufactured by Hughes Helicopters Inc. (HHI), a division of Summa Corporation. The main rotor is a four-bladed fully articulated system. It is supported by a stationary mast which transmits flight loads directly to the fuselage. The tail rotor is a four-bladed semi-rigid, delta-hinged system incorporating elastomeric teetering bearings. The rotors are driven by two General Electric YT 700-GE-700R engines through the power train shown in figure 2. An auxiliary power unit (APU) is installed primarily for starting the engines and to provide electrical and hydraulic power when the aircraft is on the ground and rotors are not turning.The aircraft is designed to carry various combinations of ordinance internally in the ammunition bay and externally on the four wing store positions. A 30mm area weapon is mounted on a turret under the copilot/gunner cockpit. The YAH-64 is designed to operate during day, night and marginal weather combat conditions using the Martin Marietta Target Acquisition Designation System (TADS)/Pilot's Night Vision System (PNVS). The TADS, PNVS and weapon systems are described in appendix H.

DIMENSIONS AND GENERAL DATA

Main Rotor

Diameter (ft)	48
Blade chord (in.)	21.0*
Main rotor total blade area (ft^2)	166.5
Main rotor disc area (ft^2)	1809.56
Main rotor solidity (thrust weighted, no tip loss)	0.092
Airfoil	HH-02**
Twist	-9 deg
Number of blades	4
Rotor speed at 100 percent N_R (RPM)	289.3
Tip speed at 100 percent N_R (ft/sec)	727.09

Tail Rotor

Diameter (ft)	9.17
Chord constant (in.)	10
Tail rotor total blade area (ft2)	14.89
Tail rotor disc area (ft^2)	66.0
Tail rotor solidity	0.2256

Airfoil	NACA 632-414 (modified)
Twist (deg)	8.8 washout
Number of blades	4
Rotor speed at 100 percent N_R (RPM)	1403.4
Distance from main rotor mast centerline (C_L) (ft)	29.67
Tip speed at 100 percent N_R (ft/sec)	673
Teetering angle (deg)	35

<u>Horizontal Stabilizer/Stabilator</u>

Weight (lb)	77.3
Area (ft^2)	33.36
Span (ft)	10.67
Tip chord (ft)	2.65
Root chord (ft)	3.60
Airfoil	NACA 0018
Geometric aspect ratio	3.41
Incidence of chord line (deg)	Variable (45 deg leading edge up to 10 deg leading edge down)
Sweepback of leading edge (deg)	2.89
Sweepback of trailing edge (deg)	-7.23 deg (swept forward)
Dihedral (deg)	0

<u>Vertical Stabilizer</u>

Area (from boom C_L) (ft^2)	32.2
Span (from boom C_L) (in.)	113.0
Root chord (at boom C_L) (in.)	44.0
Geometric aspect ratio	2.5
Airfoil	NACA 4415 (modified)
Leading edge sweep (deg)	29.4
Vertical stabilizer trailing edge deflection	16 deg left above W.L. 196.0

<u>Wing</u>

Span (ft)	16.33
Mean aerodynamic chord (in.)	45.9
Total area (ft^2)	61.59
Airfoil at root	NACA 4418

*Includes tips
**Outer 20 in. swept 20 deg and transitioned to an NACA 006 airfoil

Aircraft

Fuel quantity (gals.)	369
Design gross weight (lb)	14525
Maximum gross weight (lb)	17850

FLIGHT CONTROL DESCRIPTION

General

2. The YAH-64 helicopter employs a single hydromechanical irreversible flight control system. The hydromechanical system is mechanically activated with conventional cyclic, collective and directional pedal controls, through a series of push-pull tubes attached to four airframe-mounted hydraulic servoactuators. The four hydraulic servoactuators control longitudinal cyclic, lateral cyclic main rotor collective and tail rotor collective pitch. Cylic and directional servoactuators incorporate integral SAS actuators. Hydraulic power is supplied by two independent 3000-psi hydraulic systems which are powered by hydraulic pumps mounted on the accessory gearbox to allow full operation under a dual-engine failure condition. A Digital Automatic Stabilization Equipment (DASE) system is installed to provide rate damping. The DASE control authority is limited to 10 percent of pilot control authority in pitch, roll, and yaw. The DASE also provides attitude hold and a Hover Augmentation System. An electrically actuated horizontal stabilator is normally attached to the lower aft side of the vertical stabilator. For this test, the stabilator was removed and a weight was attached to the aircraft to simulate the mass of the stabilator. A Trim Feel System (TFS) is incorporated in the cyclic and pedal controls to provide a control force gradient with control displacement from a selected trim position. A trim release switch located on the cyclic grip, provides a momentary interruption of the TFS in all axes simultaneously to allow the cyclic or pedal controls to be placed in a new trim position.

Cyclic Control System

3. The cyclic control system (fig. 3) consists of dual-tandem cyclic controls attached to individual support assemblies in each cockpit. The support assembly houses the primary longitudinal and lateral control stops, and two linear variable displacement tranducers (LVDT) designed to measure electrically the longitudinal and lateral motions of the cyclic for DASE computer inputs. A series of push-pull tubes and bellcranks transmits the motion of

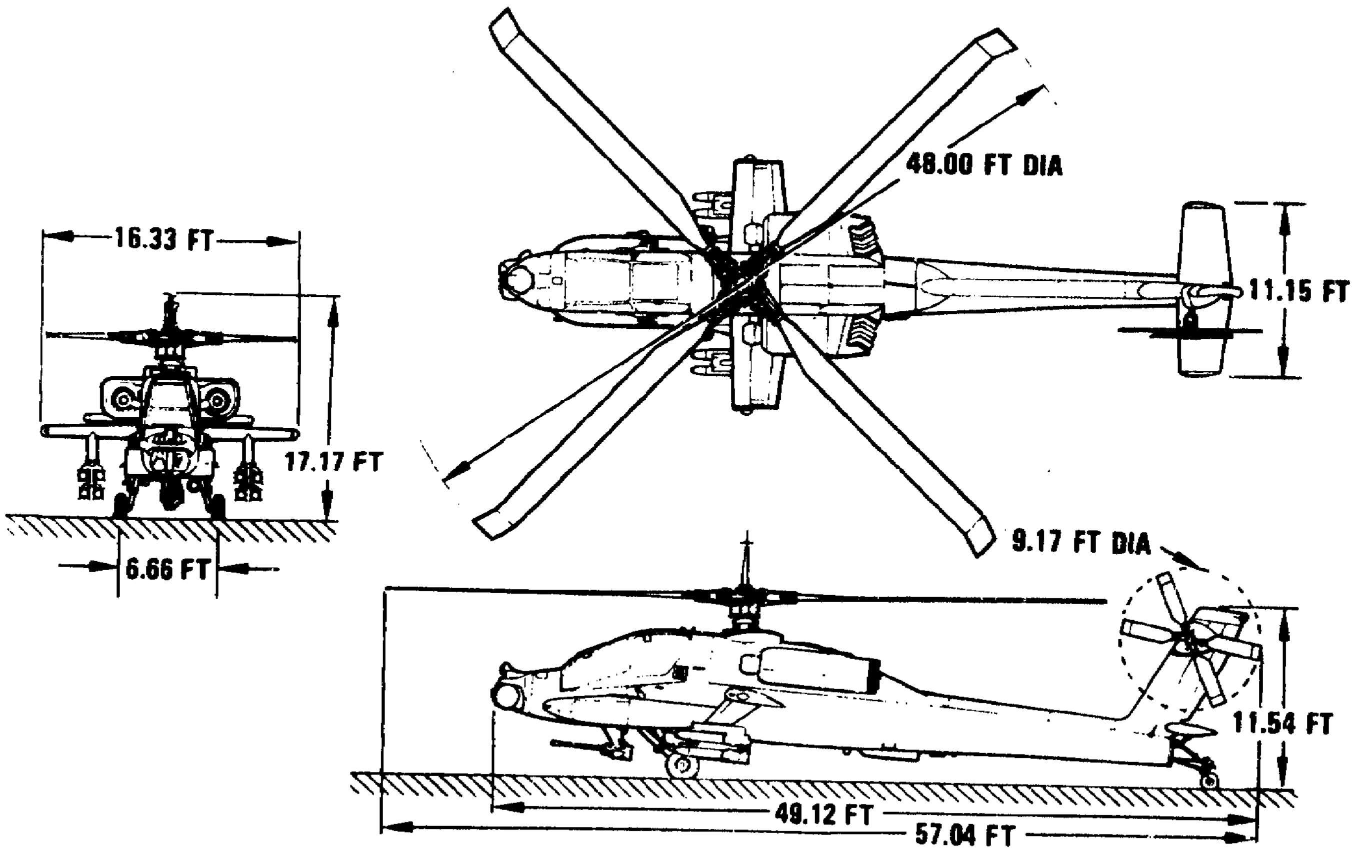


Figure 1. Aircraft Dimensions

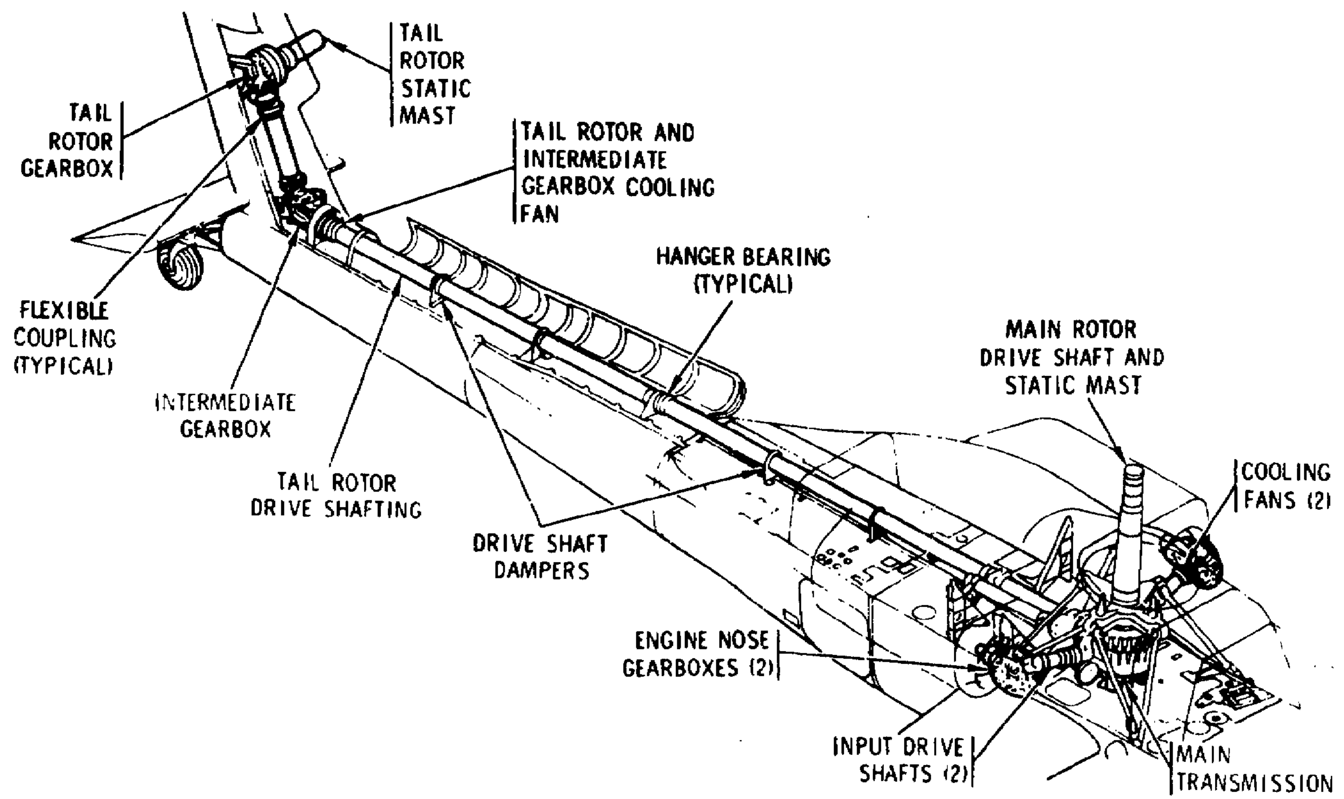


Figure 2. Powertrain

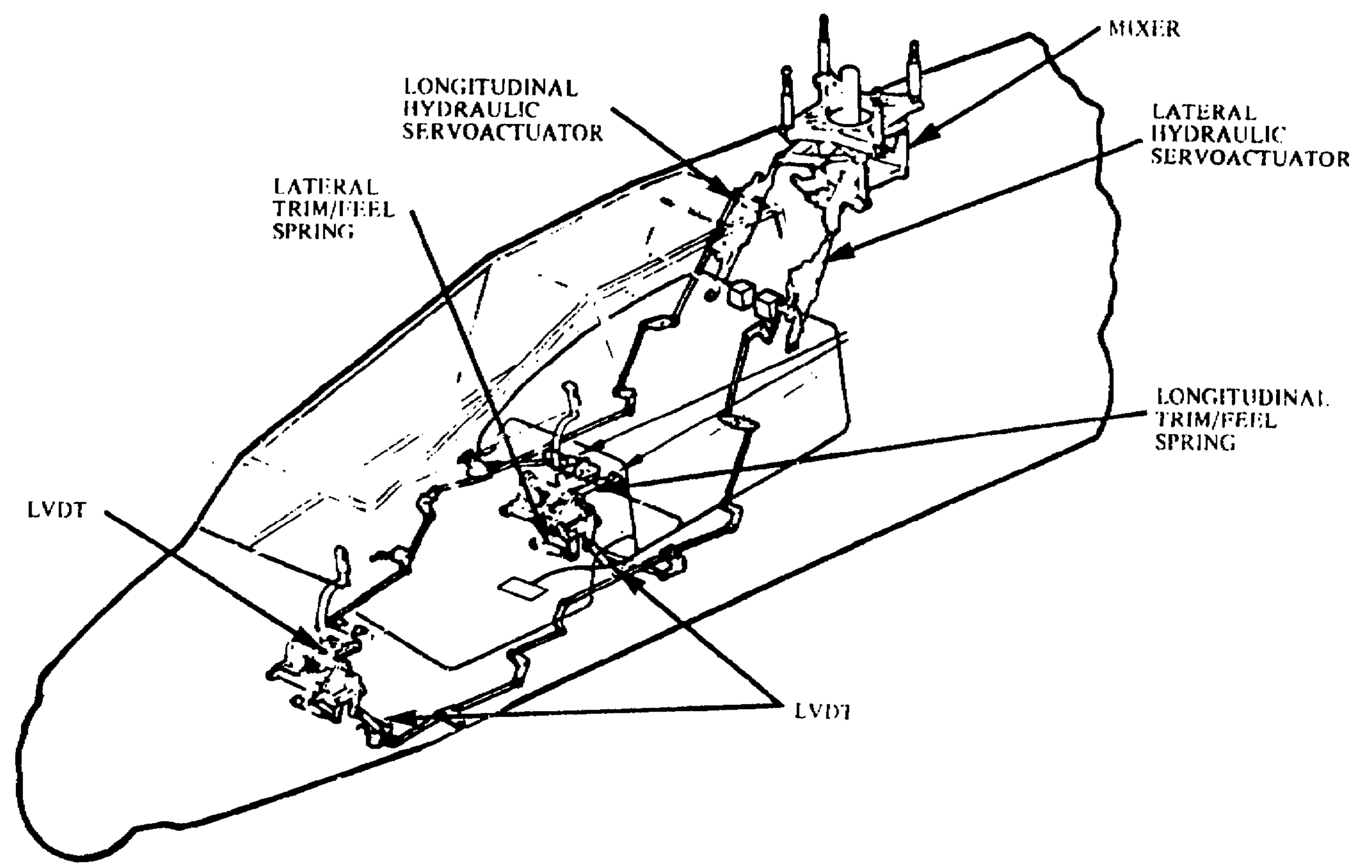


Figure 3. Cyclic Control System

the cyclic control to the servoactuators and the mixer assembly. Motion of the mixer assembly positions the nonrotating swashplate. which transmits the control inputs to the rotating swashplate to control the main rotor blades in cyclic pitch (fig. 4). A stick fold linkage is provided to allow the copilot/ gunner (CPG) to lower the cyclic stick to prevent interference when operating the weapon systems.

Collective Control System

4. The collective pitch control subsystem (fig. 5) consists of dual-tandem controls which transmit collective control inputs to the main rotor through a series of push-pull tubes and bellcranks attached to the collective servoactuator. Motion of the servo-actuator is transmitted through the mixer assembly to the swashplate to control the main rotor blades in collective pitch. Collective inputs are also transmitted to the load demand spindle of each engine hydromechanical unit (HMU). The HMU meters the fuel as appropriate to provide collective pitch compensation. Located at each collective control base assembly are the primary control stop, an LVDT, and a 1 g balance spring. The LVDT supplies electrical inputs to the stabilator control units.

Directional Control System

5. The directional control system (fig. 6) consists of a series of push-pull tubes and bellcranks which transmits directional pedal inputs to the tail rotor hydraulic servoactuator located in the vertical stabilizer. Attached to each directional pedal assembly are the primary tail rotor control stops and one LVDT. Two sets of wheel brake cyclinders are attached to the directional pedals and a 360-degree swiveling tail wheel is incorporated. The tail wheel may be locked in the trailing position by means of a switch located on the pilot's instrument panel. The tail wheel was removed to accomodate the tie down structure for this test.

Trim Feel System

6. A trim feel system (TFS) is incorporated in the longitudinal, lateral, and directional control systems. The TFS uses individual magnetic brake clutch assemblies in each of the control linkages. Trim feel springs are incorporated to provide a control force gradient and positive control centering. The electromagnetic brake clutch is powered by 28 VDC and is protected by the trim circuit breaker. A complete DC electrical failure will disable the TFS and allow the cyclic and directional pedals to move freely without from the trim feel springs. The trim release

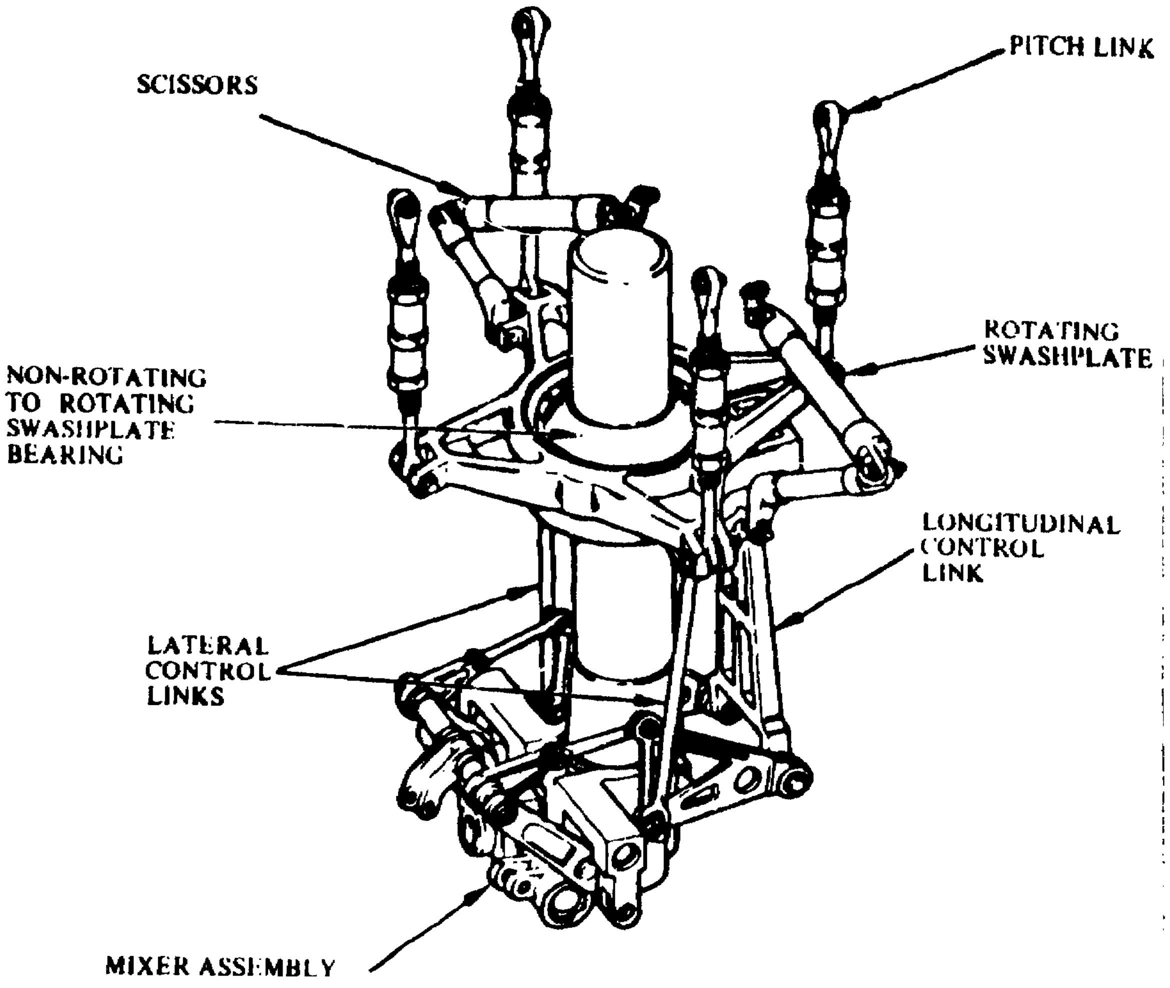


Figure 4. Main Rotor Swashplate Assembly

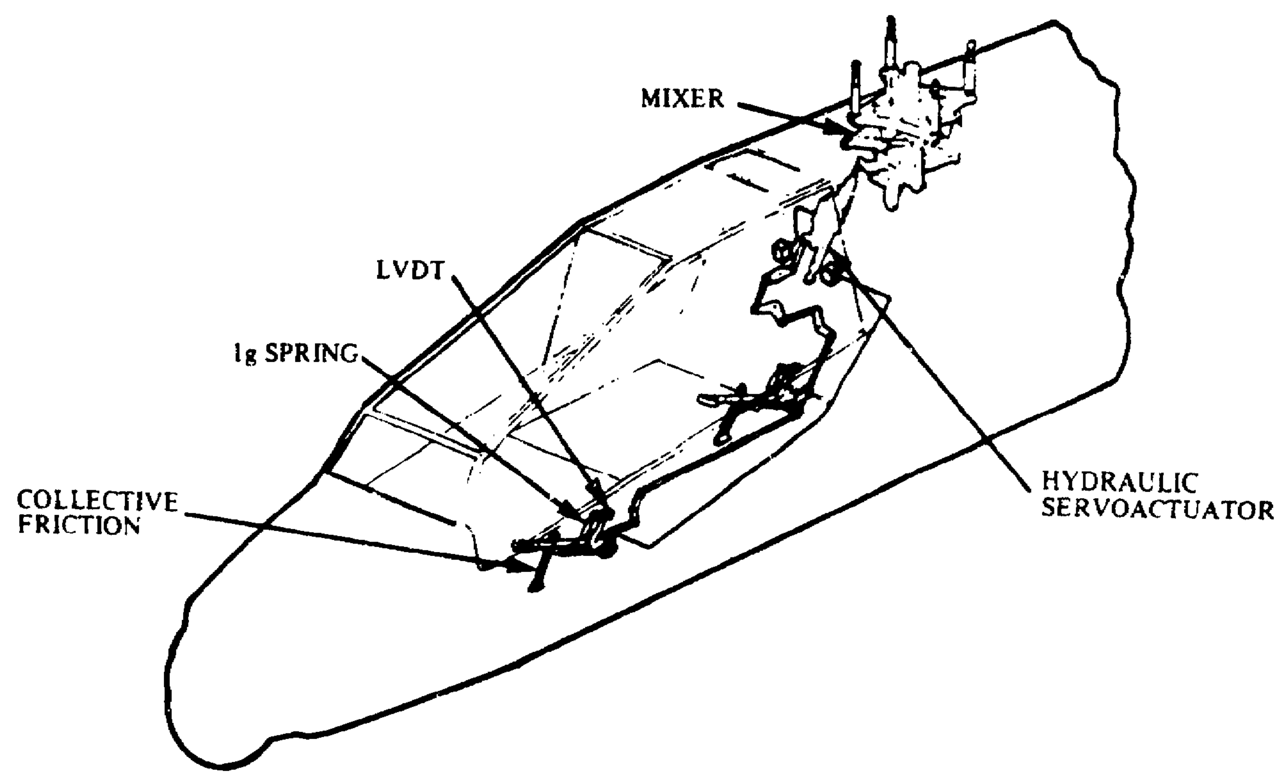


Figure 5. Collective Control Subsystem

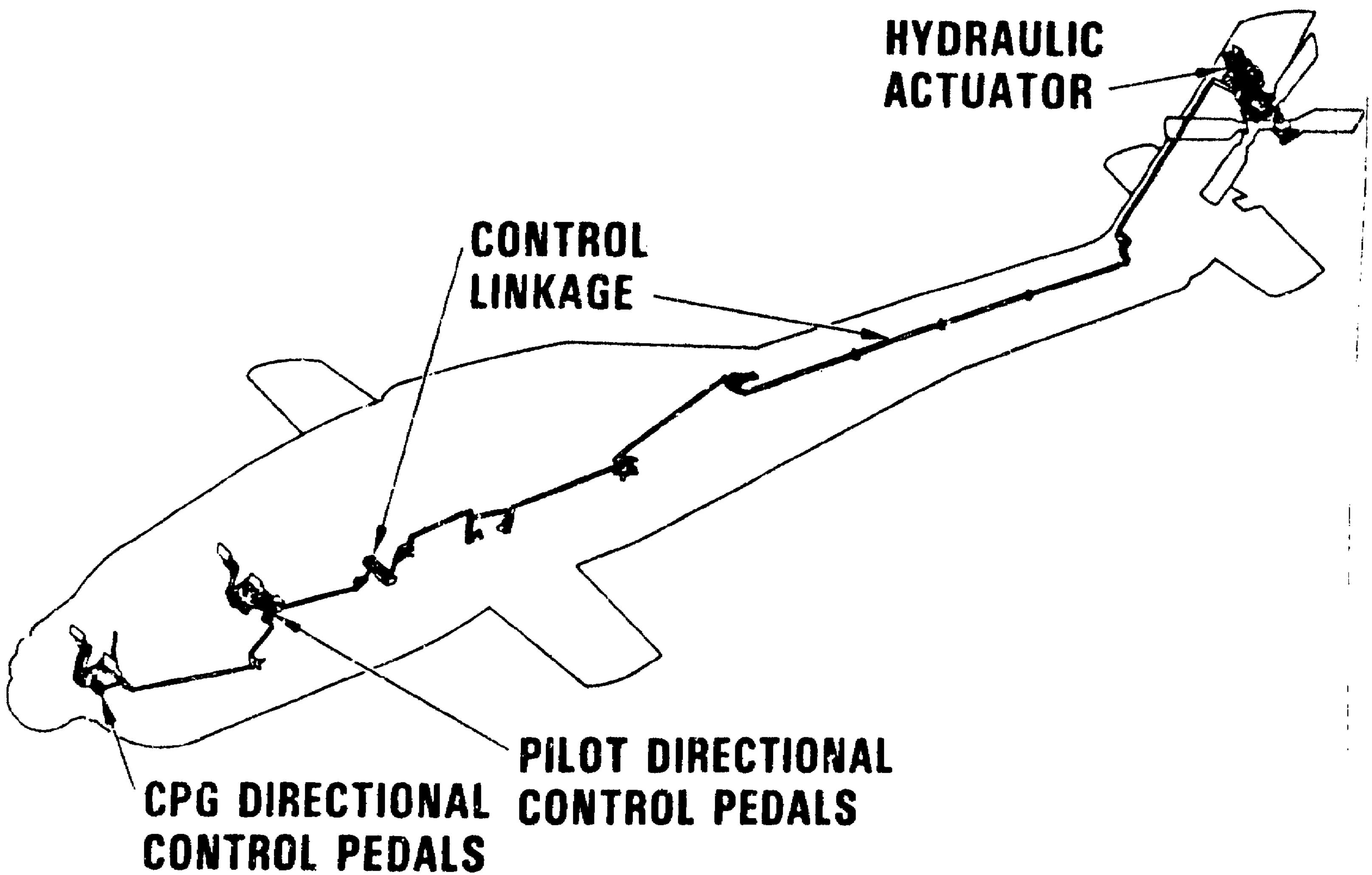


Figure 6. Directional Controls

switch on the pilot's cyclic grip allows momentary release of the TFS. The CPG also has a momentary release capability.

Horizontal Stabilator

7. The horizontal stabilator is attached to the aft lower portion of the vertical stabilizer. A dual, series 28 VDC electro-mechanical actuator allows incidence changes of +45 to -10 degrees leading edge up (LEU) of travel. Safety features include an automatic shutdown capability which allows operation in the manual mode by means of a stabilator control panel located on each collective stick. An audio tone is associated with the failure of the automatic mode of operation. A stabilator kill switch, located on the pilot's collective stick, disables both the automatic and manual operation to protect against a hardover failure. There are three modes of stabilator operation: the automatic mode, the NOE/Approach mode and the manual mode.

Flight Control Rigging

8. A flight controls rigging check was performed in accordance with procedures outlined in HHI Experimental Test Procedure (ETP) 7-211500000, dated 1 December 1980 (main and tail rotor controls). Table 1 presents the main rotor rigging.

9. Tail rotor rigging is shown below:

Full right pedal: 14.7 degrees of collective blade angle (thrust to left)

Full left pedal: 27.2 degrees of collective blade angle (thrust to right)

Digital Automatic Stabilization Equipment

10. The DASE provides rate damping stability augmentation system (SAS), control augmentation (CAS), hover augmentation (HAS), attitude hold, and turn coordination. The DASE is controlled by the digital automatic stablization equipment computer (DASEC). The DASEC receives information from several sources. The heading and attitude reference system (HARS) provides the DASEC with aircraft angular velocities (3 axes), aircraft attitudes (pitch and roll), and inertial horizontal velocity (measured by the Doppler radar). The Air Data System (ADS) provides lateral and longitudinal airspeed, and sideslip angle. The LVDT's provide longitudinal, lateral, and directional control position information. The electronic attitude direction indicator (EADI) provides turn rate. The DASEC processes this

Table 1. Main Rotor Rigging

	Travel (deg)
LONGITUDINAL CYCLIC	
1. Forward	20.7
2. Aft	9.7
LATERAL CYCLIC	
1. Left	11.5
2. Right	7.3
COLLECTIVE	
1. Full pitch travel	16.4
2. Collective pitch full down Measured @ pitch housing (Bolt pad machined surface 2.4 inches inboard of lead-lag hinge)	-7.2

information and commands control inputs through the electro-hydraulic servo valves on the longitudinal, lateral, and directional servoactuators.

HYDRAULIC SYSTEM

General

11. The hydraulic system consists of four hydraulic servoactuators powered simultaneously by two independent 3000-psi hydraulic systems.Each servoactuator simulataneously receives pressure from the primary and utility systems to drive the dual-tandem actuators. This design allows the remaining system to automatically continue powering the servos in the event of a single hydraulic system failure.The two systems (primary and utility) are driven by the accessory gearbox utilizing variable displacement pumps, independent reservoirs and accumulators. The APU drives all accessories, including the hydraulic pumps, when the aircraft is on the ground and the rotor is not turning. The accessory gearbox is driven by the main transmission during flight and provides for normal operation of both hydraulic systems during autorotation. An emergency hydraulic system is provided to allow emergency operation of the flight controls in the event of a dual system failure.

Primary Hydraulic System

12. The primary hydraulic system (fig. 7) consists of a one-pint capacity reservoir, and a primary manifold that directs the fluid to the lower side of the four servoactuators. The primary system also provides the hydraulic pressure for operation of the DASE.

Utility Hydraulic System

13. The utility hydraulic system (fig. 8) consists of an air pressurized 1.3 gallon reservoir and an accumulator which is pressurized to 3000 psi to drive the APU start motor. The accumulator has a nitrogen precharge at all temperatures. A second gas reservoir which doubles the nitrogen capacity to approximately 310 cubic inches was installed for operations below-25°F. The utility manifold directs pressurized fluid to the upper side of the servoactuators, the stores pylon system, tail wheel lock mechanism, area weapon turret drive, and rotor brake. Other manifold functions include an auxiliary isolation check valve which isolates the area weapon turret drive and external stores actuators when either a low pressure or low fluid

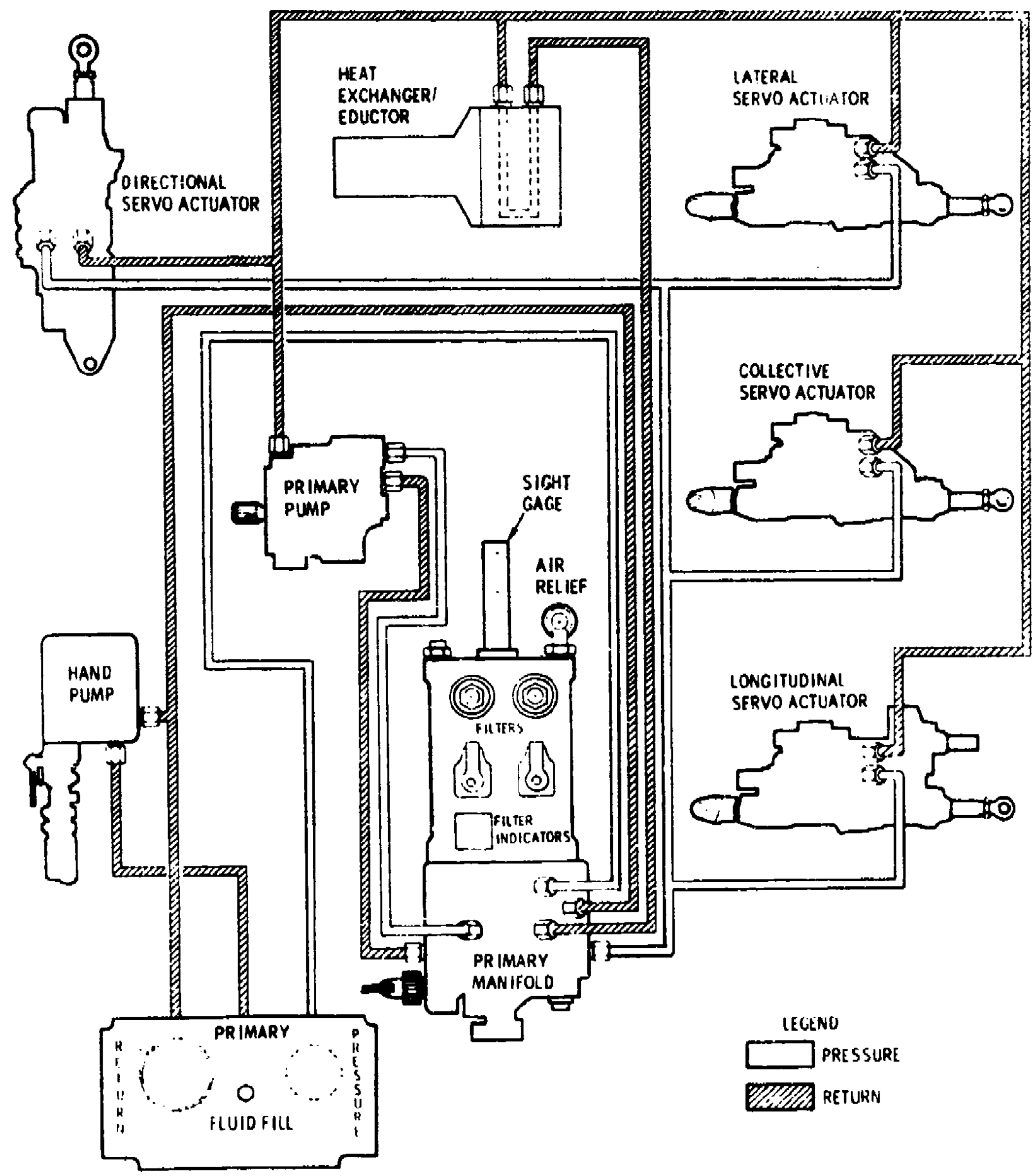


Figure 7. Primary Hydraulic System

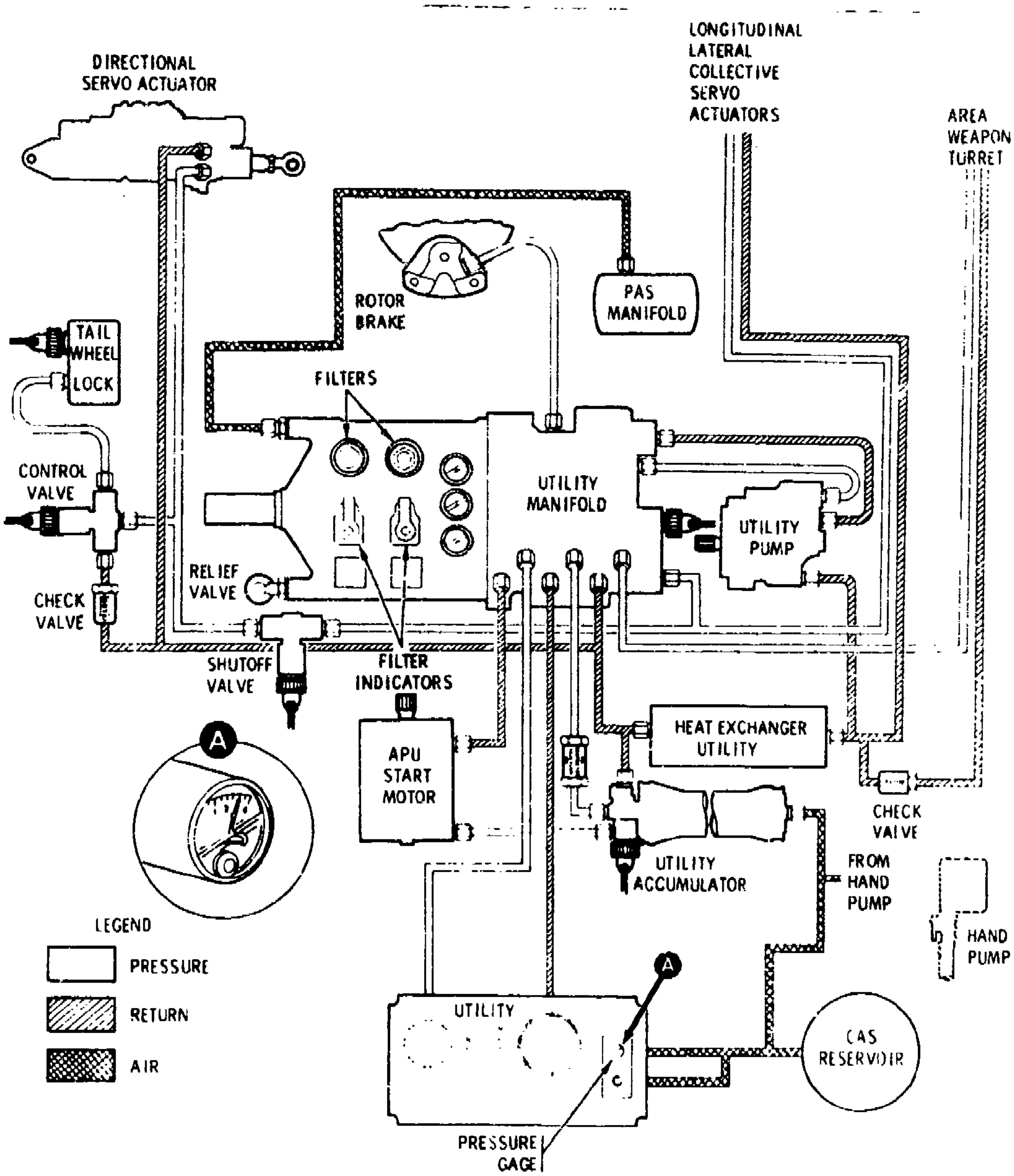


Figure 8. Utility Hydraulic System

condition exists; a low pressure sensor isolates the accumulator as an emergency hydraulic source for the servoactuators in the event of a dual hydraulic system failure. The accumulator assembly stores enough fluid for emergency operation of the flight controls through four full strokes of the collective stick and one 180 degree heading change. The emergency system may be activated by either the pilot's or CPG's emergency switch. An electrically activated emergency shutoff valve is designed to isolate the utility side of the directional servoactuator and the tail wheel lock mechanism when a low fluid condition exists.

Servoactuators

14. Individual hydraulic servoactuators are provided for longitudinal, lateral, collective, and directional controls. Each servoactuator (fig. 9) consists of a ballistically tolerant housing, a single actuator rod and dual frangible pistons, back up control System (BUCS) plunger, and various parts for routing of both primary and utility hydraulic fluid. The system is designed to accommodate all flight loads with a failure of either system. However, DASE and BUCS functions would be lost with failure of the primary system. The BUCS plunger assemblies were installed during this test, however, electrical connections were omitted.

Hand Pump

15. A hand pump is installed next to the ground support equipment panel on the right side of the helicopter. It provides one method of charging the utility accumulator, as well as a method for the ground crew to service the primary and utility reservoirs. A lever near the pump may be moved to any of three positions to open one of three mechanically operated check valves to the accumulator or to either reservoir.

POWER PLANT

16. The power plant for the YAH-64 helicopter is the General Electric YT 700-GE-700R front drive turboshaft engine, rated at 1563 shp (sea level, standard day, uninstalled). The engines are mounted in nacelles on either side of the main transmission. The basic engine consists of four modules: A cold section, a hot section, a power turbine, and an accessory section. Design features of each engine include an axial/centrifugal flow compressor, a through-flow combustor, a two-stage air-cooled high-pressure gas generator turbine, a two-stage uncooled power turbine, and self-contained lubrication and electrical systems.

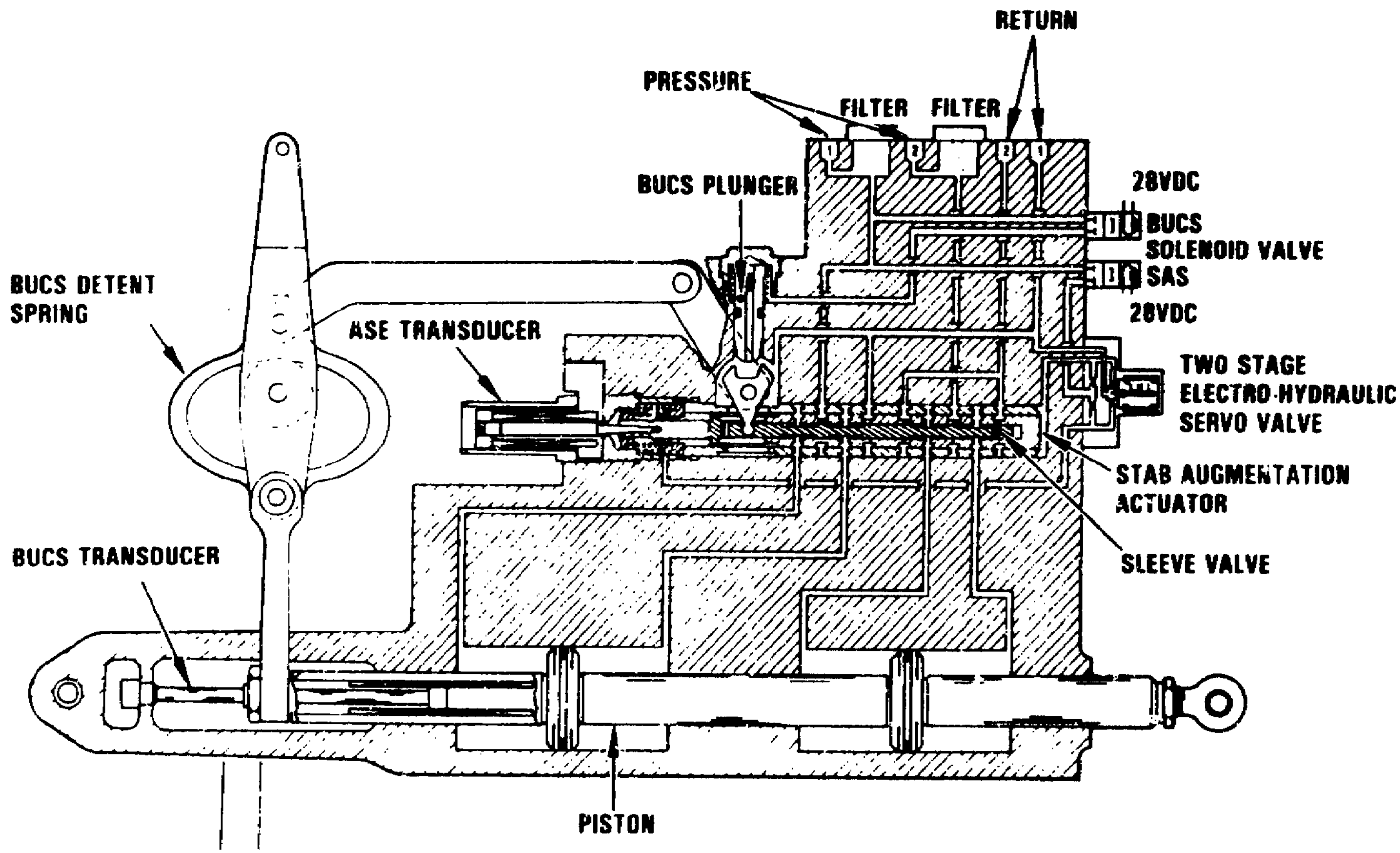


Figure 9. Flight Control Servoactuator

In order to reduce sand and dust erosion, and foreign object damage, an integral particle separator operates when the engine is running. The YT 700-GE-700R engine also incorporates a history recorder which records total engine events. Engines S/N 207-263R and 207-241R were installed in the left and right positions, respectively. Pertinent engine data are shown below:

Model	YT 700-GE-700R
Type	Turboshaft
Rated power (intermediate)	1563 shp sea level, standard day, uninstalled
Output speed (at 100 percent N_R)	20,952 RPM
Compressor	5 axial stages, 1 centrifugal stage
Variable geometry	Inlet guide vanes, stages 1 and 2 vanes
Combustion chamber	Single annular chamber with axial flow
Gas generator turbine stages	2
Power turbine stages	2
Direction of rotation (aft looking forward)	Clockwise
Weight (dry)	415 lb
Length	46.5 in
Maximum diameter	25 in.
Fuel	MIL-L-5624 (JP4 or JP5)
Lubricating oil	MIL-L-7808 or MIL-L-23699

Electrical power requirements for history recorder and Np overspeed protection HZ	40W, 115 VAC, 400
Electrical power requirements for anti-ice valve, filter bypass indication, oil filter bypass indication, and magnetic chip detector	1 amp, 28 VDC

INFRARED (IR) SUPPRESSION SYSTEM

17. The IR suppression consists of finned exhaust pipes attached to the engine outlet and bent outboard to mask hot engine parts. The finned pipes radiate heat and are cooled by rotor downwash in hover and turbulent air flow in forward flight. The engine exhaust plume is cooled by mixing it with engine cooling air and bay cooling air (fig. 10). The exhaust acts as an eductor, creating air flow over the combustion section of the engine providing engine cooling. Fixed louvers on the top and bottom of the aft cowl and a door on the bottom forward cowling provide convective cooling to the engine during shutdown. The movable bottom door is closed by engine bleed air during engine operation.

FUEL SYSTEM

18. The YAH-64 fuel system has two fuel cells located fore and aft of the ammunition bay. The system includes a fuel boost pump in the aft cell for starting and for high-altitude operation, a fuel transfer pump for transferring fuel between cells, a fuel crossfeed/shutoff valve, and provisions for pressure and gravity fueling and defueling. Additionally, provisions exist for external, wing-mounted fuel tanks. Figure 11 is a schematic of the fuel system. Figure 12 shows the locations and capacities of the two internal fuel cells.

19. By using the tank select switch on the fuel control panel, the pilot can select either or both tanks from which the engines will draw fuel. With the crossfeed switch in the normal (NRML) position, the left (No. 1) engine will draw fuel from the forward fuel cell and the right (No. 2) engine will draw from the aft cell. When OPEN is selected on the crossfeed switch, both engines draw fuel from the fuel cell with the most fuel (highest head pressure). The crossfeed switch is disabled whenever the boost pump is on. When the boost pump is on, the fuel crossfeed valve

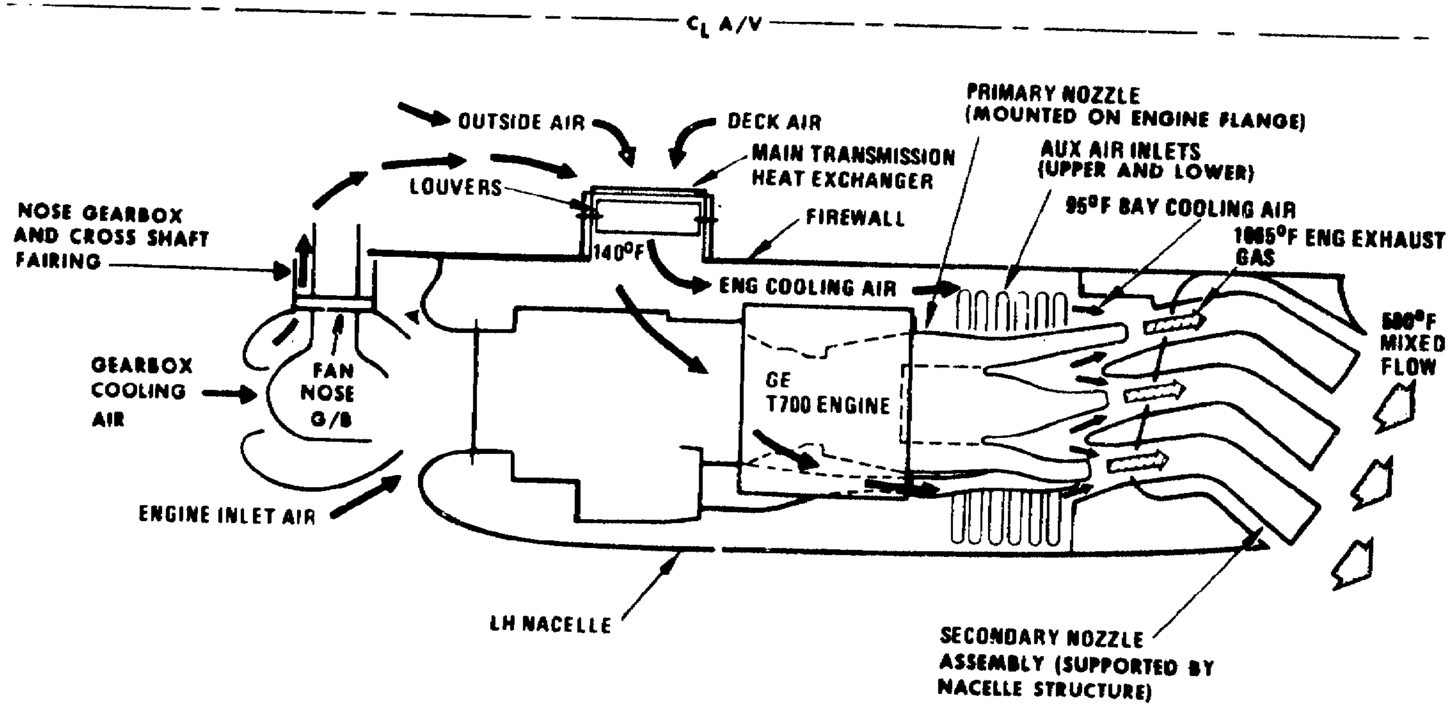


Figure 10. Infrared Supression System Engine Cooling

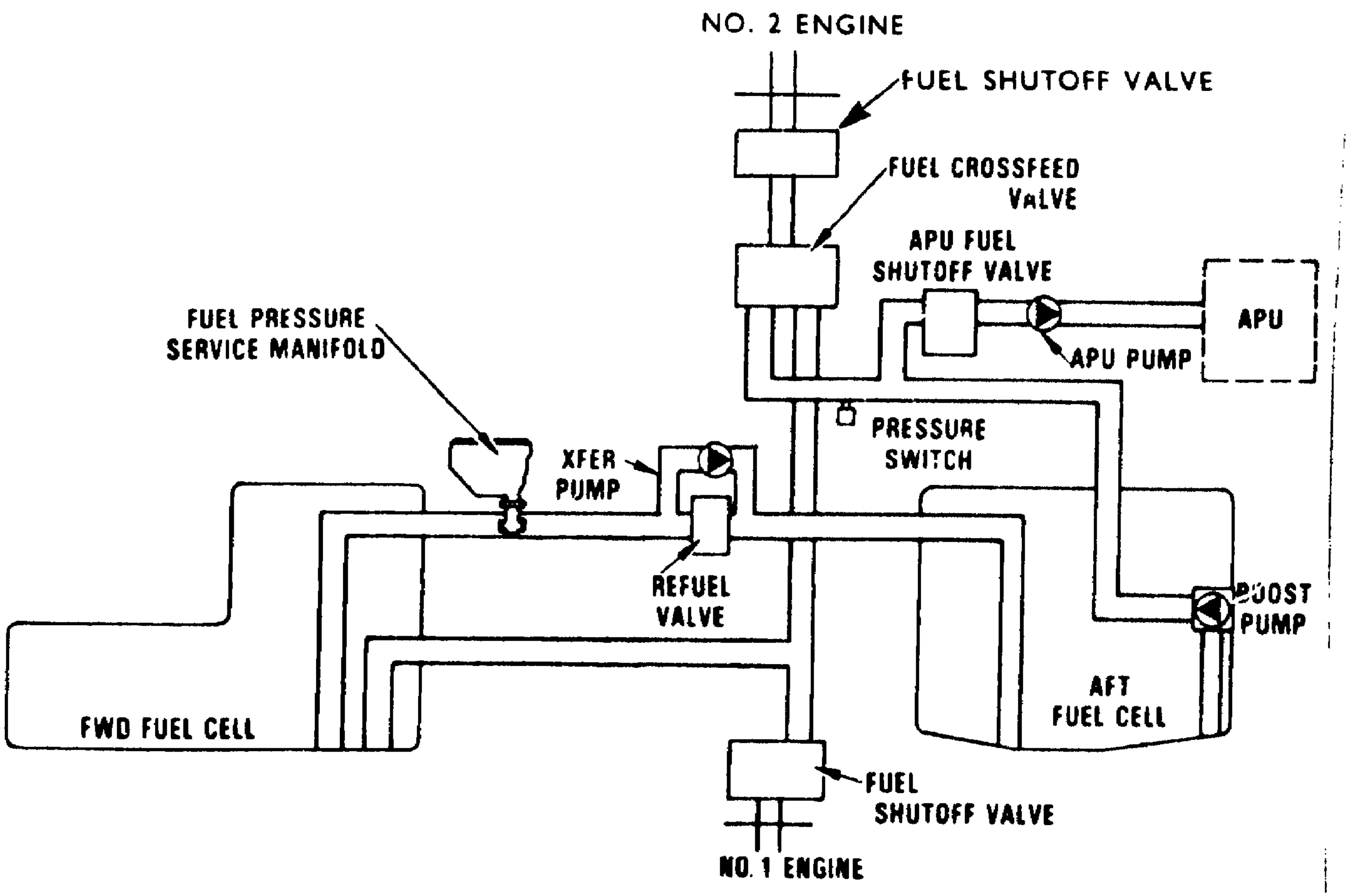


Figure 11. Fuel System Major Components

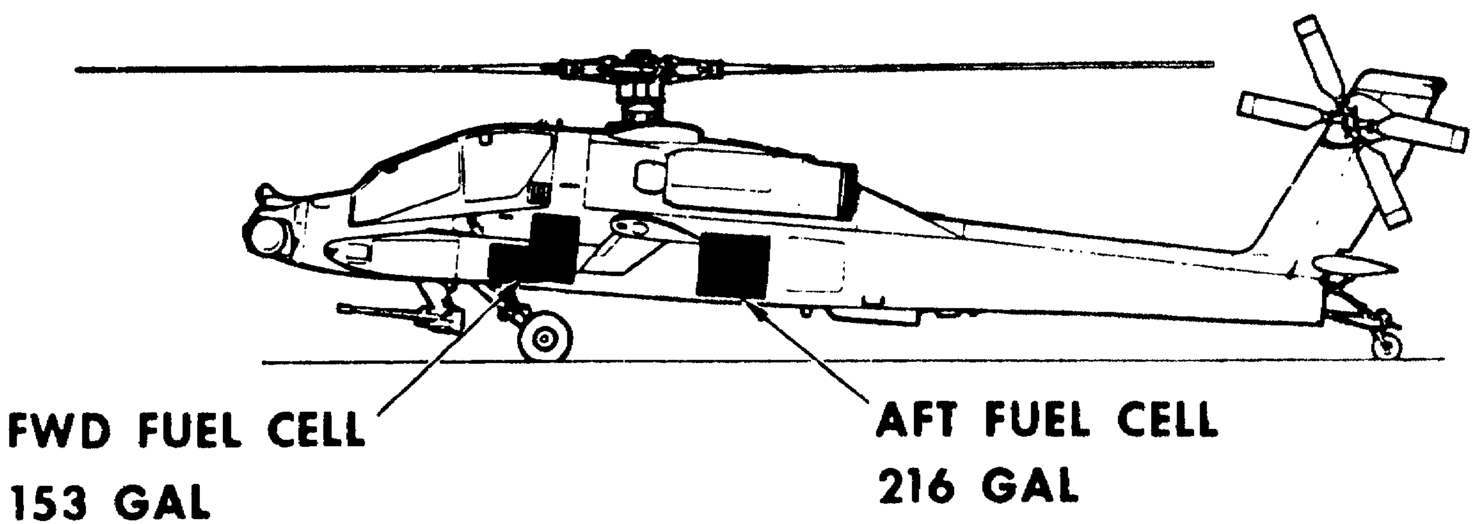


Figure 12. Fuel Cell Locations

is automatically positioned to OPEN. The air-driven boost pump operates automatically during engine start and may be activated by the switch on the pilot or CPG fuel control panel.

20. The pilot and CPG also have the capability to transfer fuel between tanks using the transfer switch on the fuel control panels. Moving the fuel transfer switch out of the OFF position closes the refuel valve and starts the air-driven pump transferring fuel in the selected direction.

TRANSMISSIONS

General

21. The aircraft has 5 transmissions; the main transmission (a part of which is called the accessory gear box), 2 engine nose gear boxes, an intermediate gear box in the tail rotor drive train, and the tail rotor gear box.

Main transmission

22. The main transmission, located below and attached to the main rotor support structure, provides the necessary change in direction and speed reduction of the engine output shafts to drive a primary and accessory drive train to turn the main and tail rotor and accessories. The main transmission is required to accept a torque load only. Lifting and bending load moments are transmitted from the main rotor, through the stationary mast and support structure, into the helicopter structure (fig 13). The main rotor drive shaft passes through the stationary mast without touching it and is splined to a drive plate which drives the main rotor hub.

23. The main transmission lubrication system has two separate galleries. Each gallery incorporates an oil sump, oil pump, low level switch, oil level sight gauge, and chip detector/temperature probe (fig 14). Both oil systems are serviced from a single filler on the right side of the tranmission and the oil intermixes during normal operation. During normal operation, oil is gravity fed to the oil pumps, passes through oil filters, heat exchangers and internal passages and screened jets to lubricate gears and bearings. The oil filter incorporates an impending bypass indicator and a differential pressure bypass valve. Oil pressure is controlled by a preset relief valve, and is monitored by pressure switches and caution panel segments for each system.

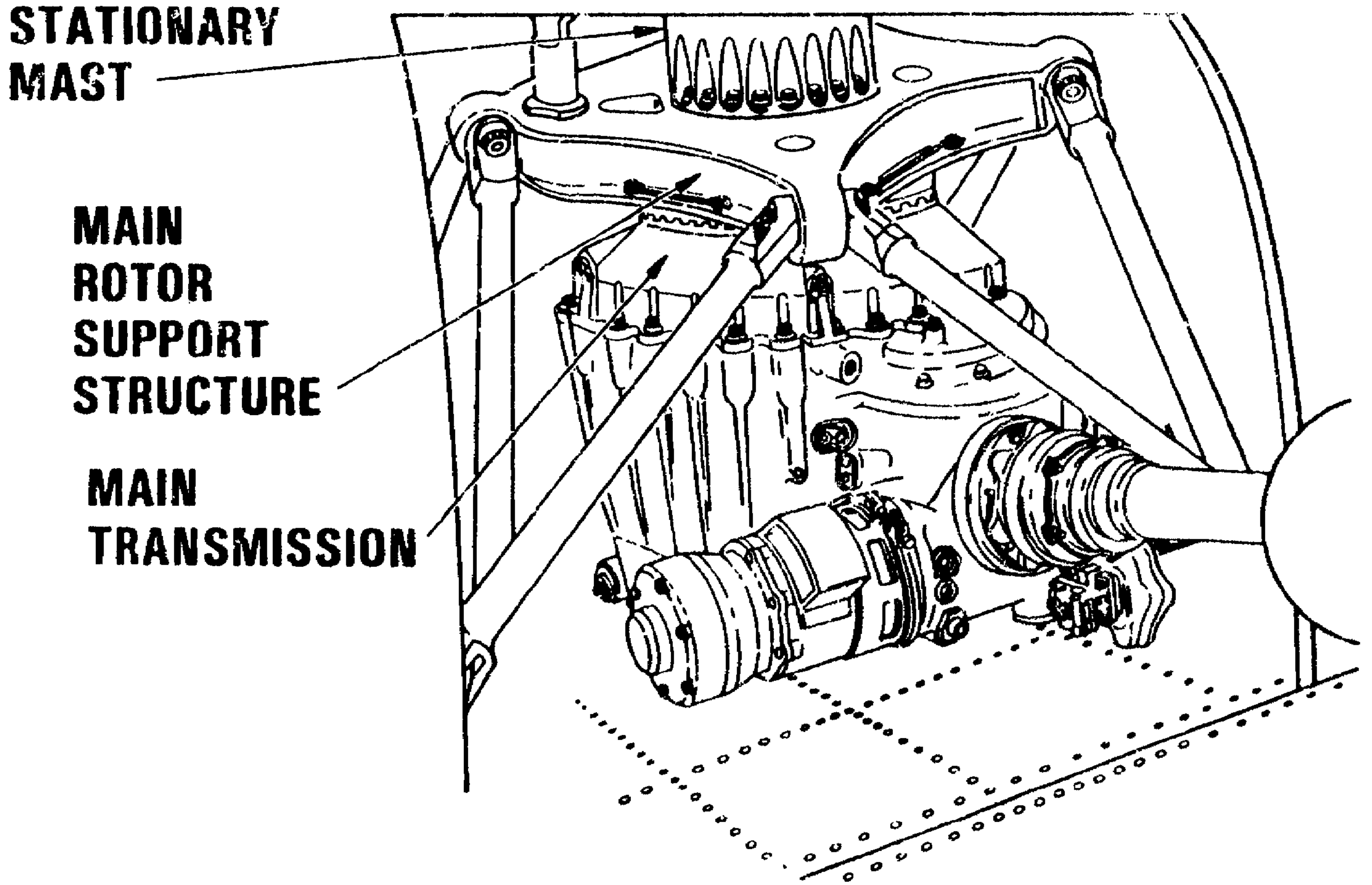
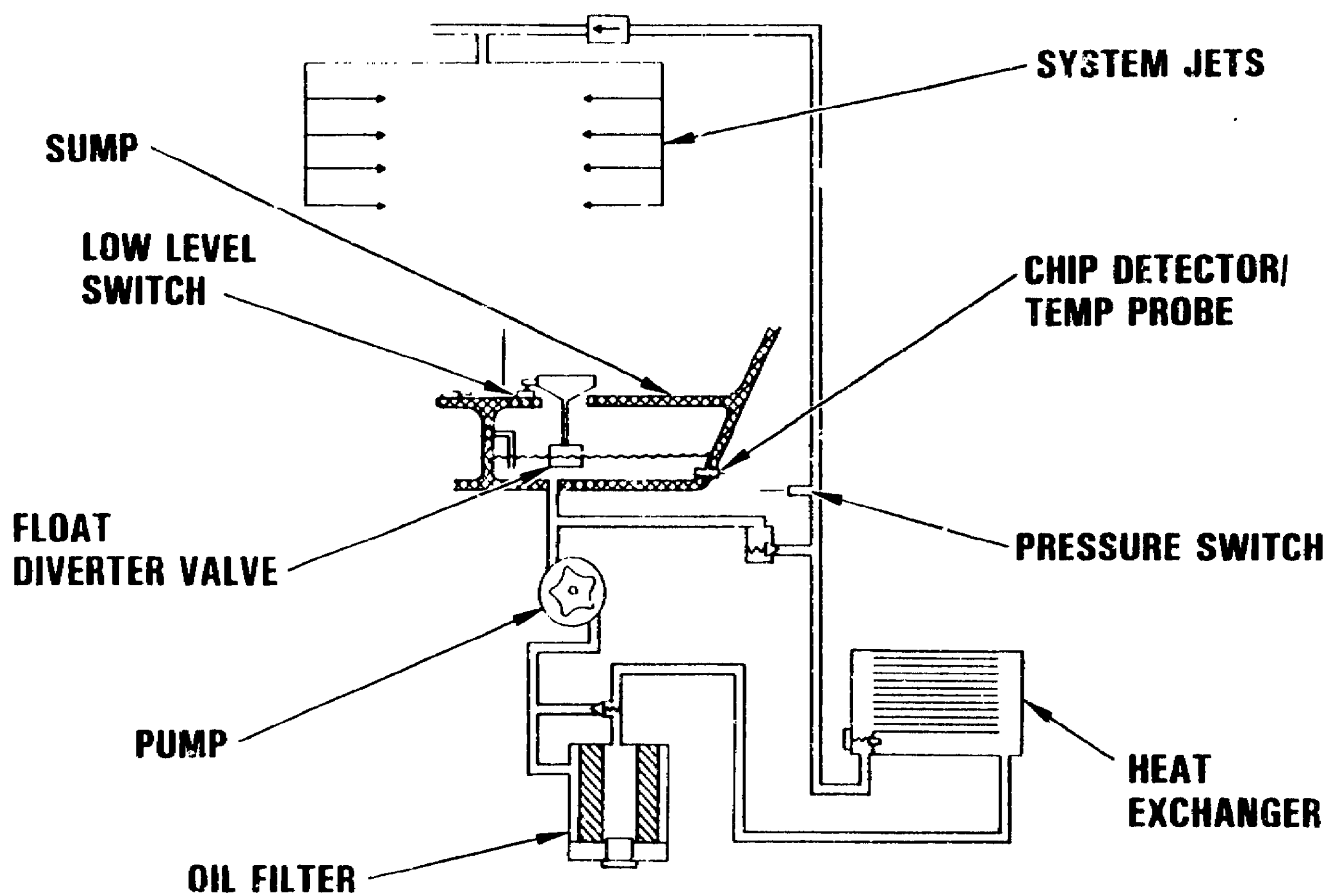


Figure 13. Main Transmission



14. Main Transmission Lubrication

Accessory Gear Box

24. The AGB is actually the accessory drive section of the main transmission. It can be driven by the main rotor or by the auxiliary power unit. The accessory gears drive two generators, two hydraulic pumps, an accessory oil pump, and a shaft driven air compressor (SDC). The AGB oil pump draws oil from the right main transmission oil sump to lubricate the accessory gears and the SDC (fig. 15). When the main rotor is not turning and the APU is operating this pump provides the only lubrication. In this mode of operation the oil does not pass through an oil cooler.

Intermediate Gearbox

25. The intermediate gearbox provides gear reduction (4892 to 3636 rpm) and a 71 degree change in direction of the tail rotor drive system (fig. 16). The intermediate gearbox has a single set of spiral bevel gears integral with an input and an output shaft. The shafts are supported by ball and roller bearing sets. Lubrication of gearbox gears and bearings is provided by special grease. Seals and baffles keep the grease within the gears and bearings. The intermediate gearbox is cooled by air blowing across its integral cooling fins. This air comes from a fan mounted on its input shaft.

Tail Rotor Gearbox

26. The tail rotor gearbox provides gear reduction (3636 to 1404 rpm) and a 90 degree change in direction of the tail rotor drive system (fig. 16). The tail rotor gearbox has a single set of spiral bevel gears integral with an input and an output shaft. Both shafts are supported by ball and roller bearing sets within the gearbox. The output shaft gets additional support from ball bearing sets within the static mast. Lubrication of the tail rotor gearbox is provided by special grease. Seals and baffles keep the grease within the gears and bearings. The tail rotor gearbox is cooled by air, blowing through its integral cooling fins, from the fan mounted on the input shaft of the intermediate gearbox.

AUXILIARY POWER UNIT

27. The aircraft is equipped with an AiResearch auxiliary power unit (APU) which develops approximately 125 shaft horsepower. The APU has a hydraulic starter driven by the utility hydraulic accumulator. The purpose of the APU is to drive the main transmission accessory gear box which, in turn, drives both hydraulic pumps, both generators and the shaft driven compressor (SDC)

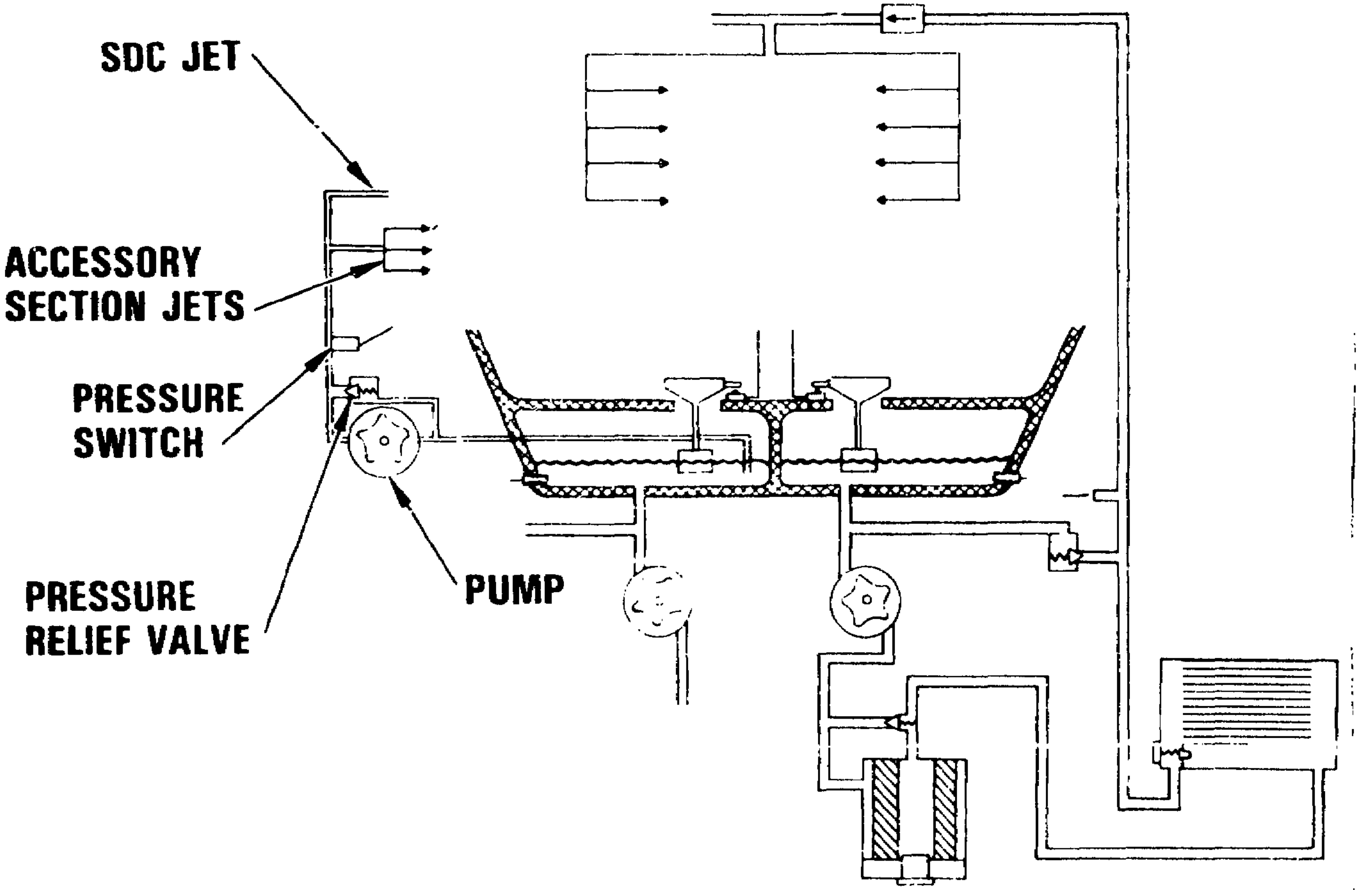


Figure 15. Accessory Drive Lubrication

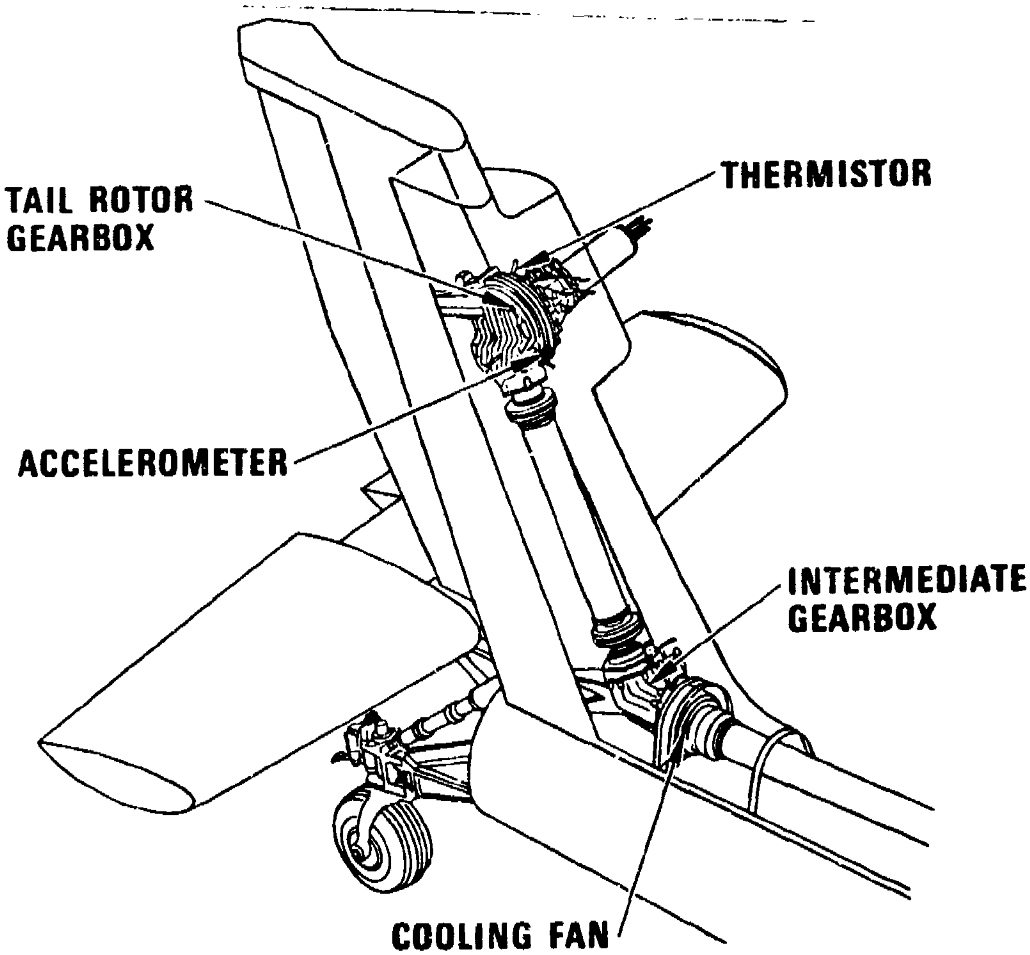


Figure 16. Intermediate and Tail Rotor Gearboxes

(fig. 17). Therefore, with the APU running, the aircraft is supplied with complete hydraulic pneumatic and electrical power. Figure 18 shows the location of the APU on the aircraft.

28. The APU control panel (fig. 19), located near the aft end of the pilot's right console, provides for operational control of the APU, APU fire warning, and control of the APU fire extinguishing system. It also provides an indication of gas generator speed (N_G). The APU control switch is a three position toggle switch, spring loaded from START to RUN, and lift locked from RUN to OFF. The switch functions are as follows:

OFF - Shuts APU down when running, normal position when APU is not in use.

RUN - Normal position when the APU is running.

START - Momentary position used to initiate the automatic start sequence. When starting the APU, the switch is manually held in this position for 2-3 seconds, then released.

The N_G indicator has a range of 0 to 120 percent, the normal indication when the APU is running is 100 percent.

29. A FIRE PULL handle is located on the APU control panel. It will illuminate when a fire is detected in the APU compartment and, when pulled, will close the APU fuel shutoff valve and arm the fire bottle select switch. The FIRE BTL select switch is spring loaded to the center position, and is used to select the fire bottle to be discharged.

30. An APU to AGB clutch is automatically engaged at approximately 60 percent APU speed during the start sequences when the rotors are not turning. When the rotors are turning, engagement occurs at approximately 90 percent speed.

PRESSURIZED AIR SYSTEM

31. The pressurized air system (PAS) provides pressurized air to various pneumatically operated aircraft components (fig. 20). The PAS is normally pressurized to 30 psi by a single-stage, centrifugal, shaft-driven compressor (SDC). The SCD (fig. 21) is mounted on and driven by the accessory gear box (AGB). It is lubricated by the AGB oil system. The throttle valve (fig. 21) closes for 60 seconds allowing initiation of the APU start sequence to reduce the starting loads on the APU. There are two alternate sources of pressurized air for the PAS, an external air recepticle

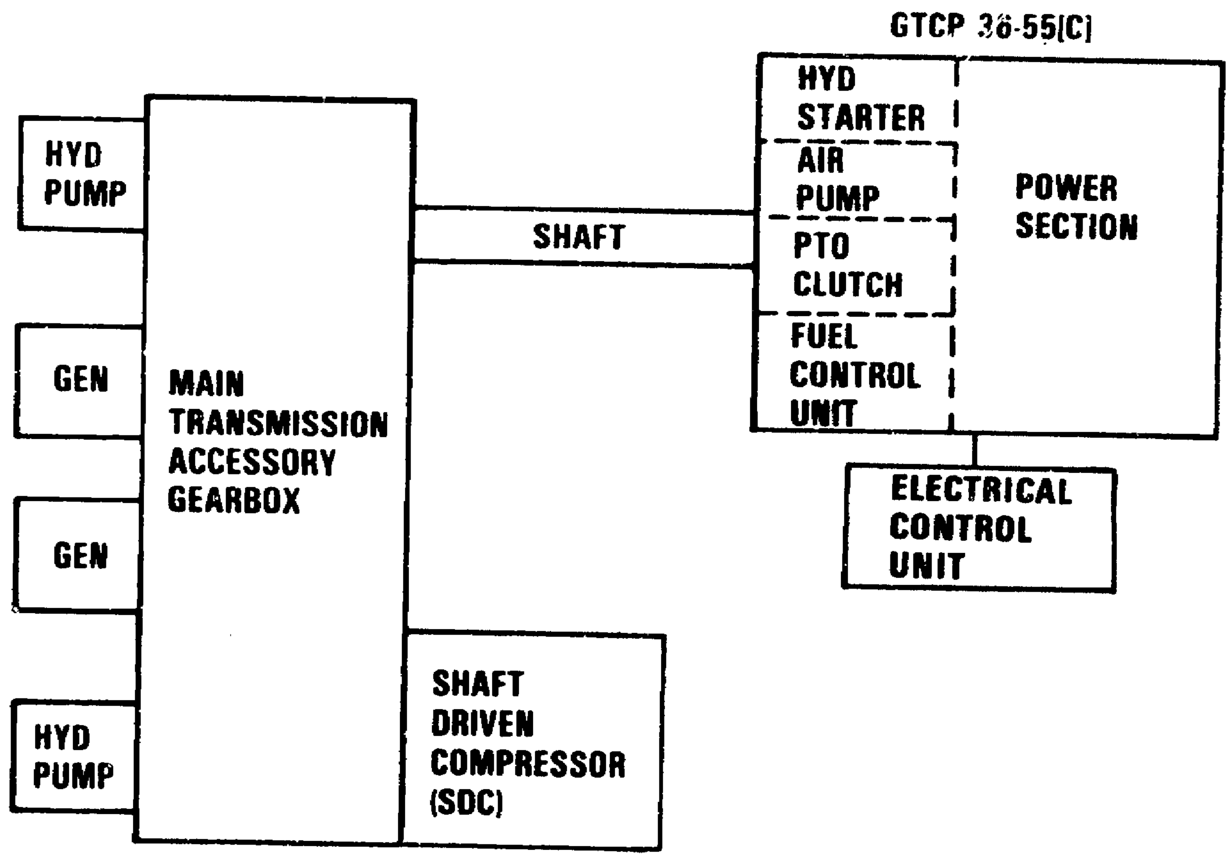


Figure 17. APU Driven Accessories Block Diagram

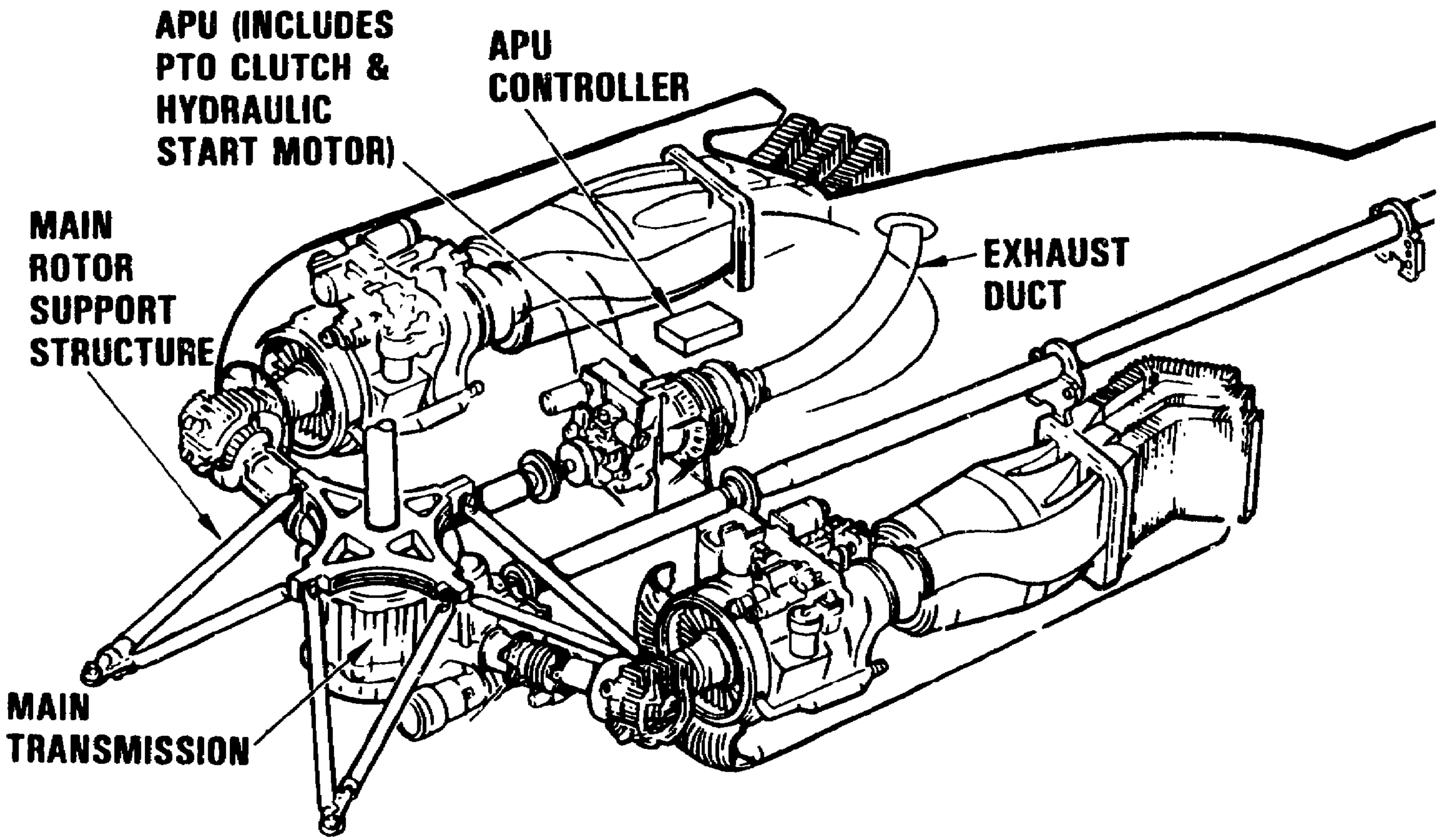


Figure 18. APU Component Locations

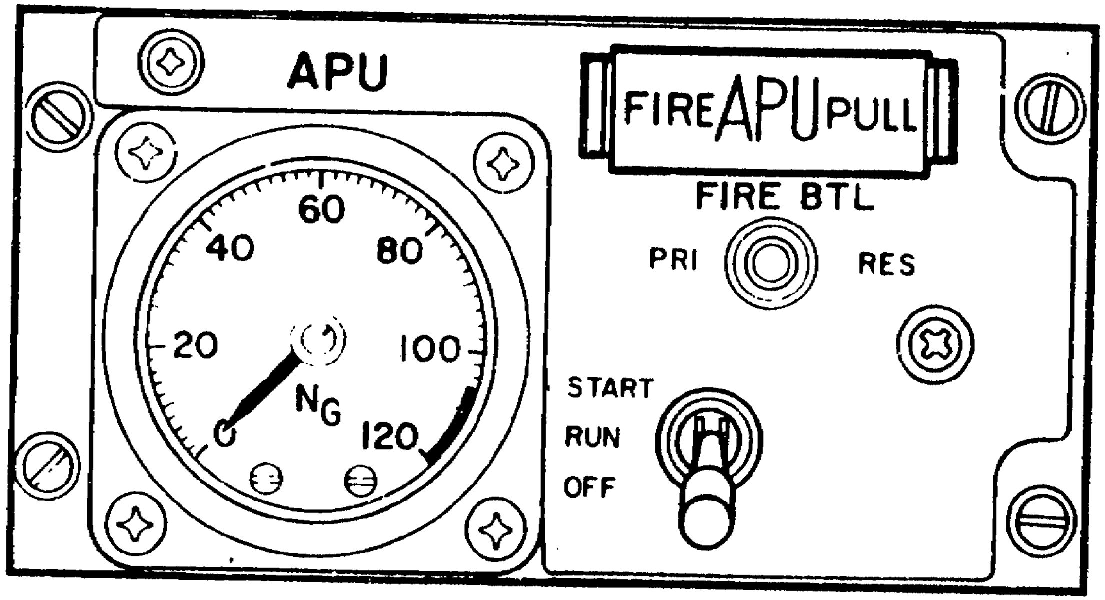


Figure 19. APU Control Panel

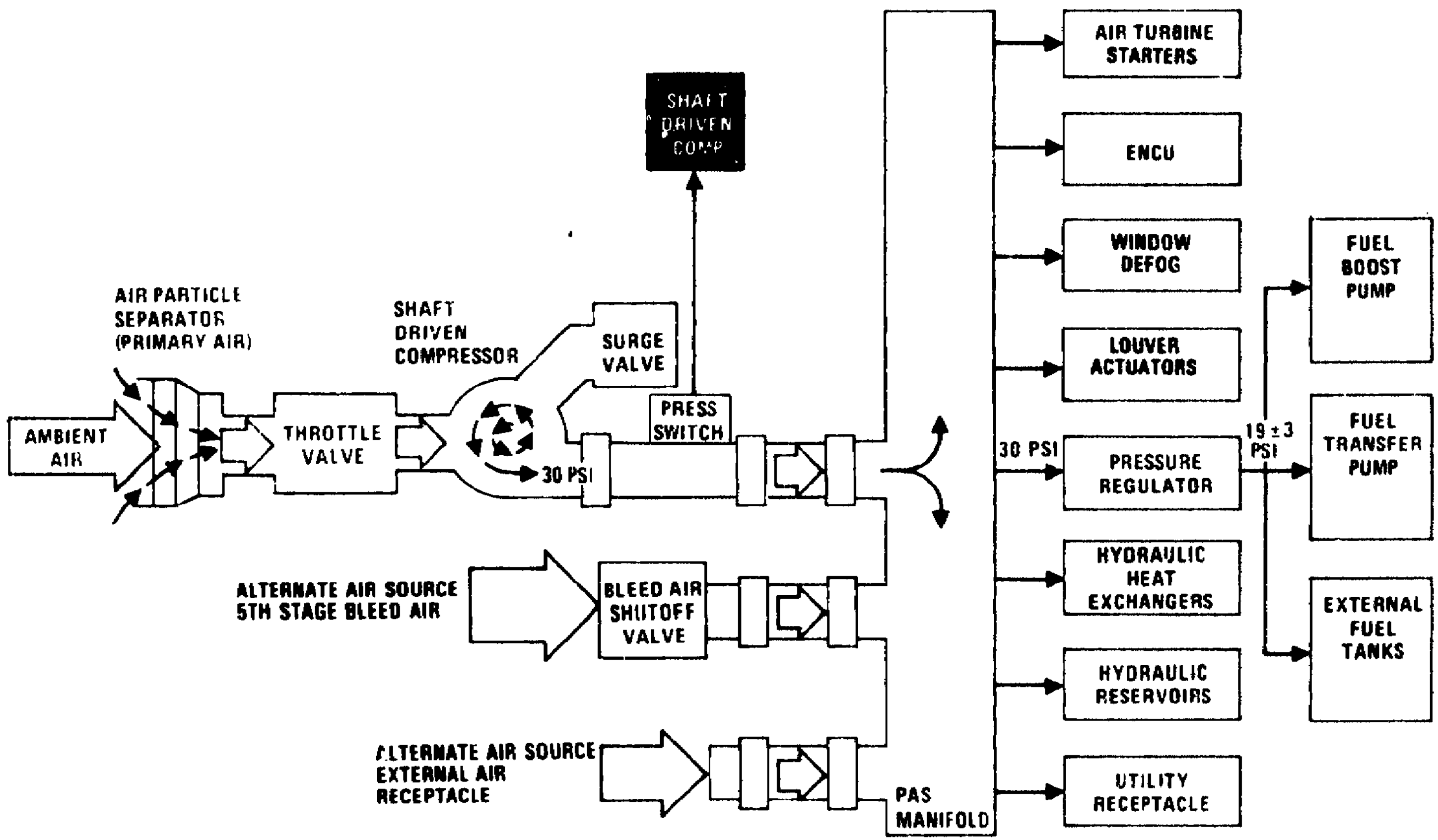


Figure 20. Pressurized Air System Block Diagram

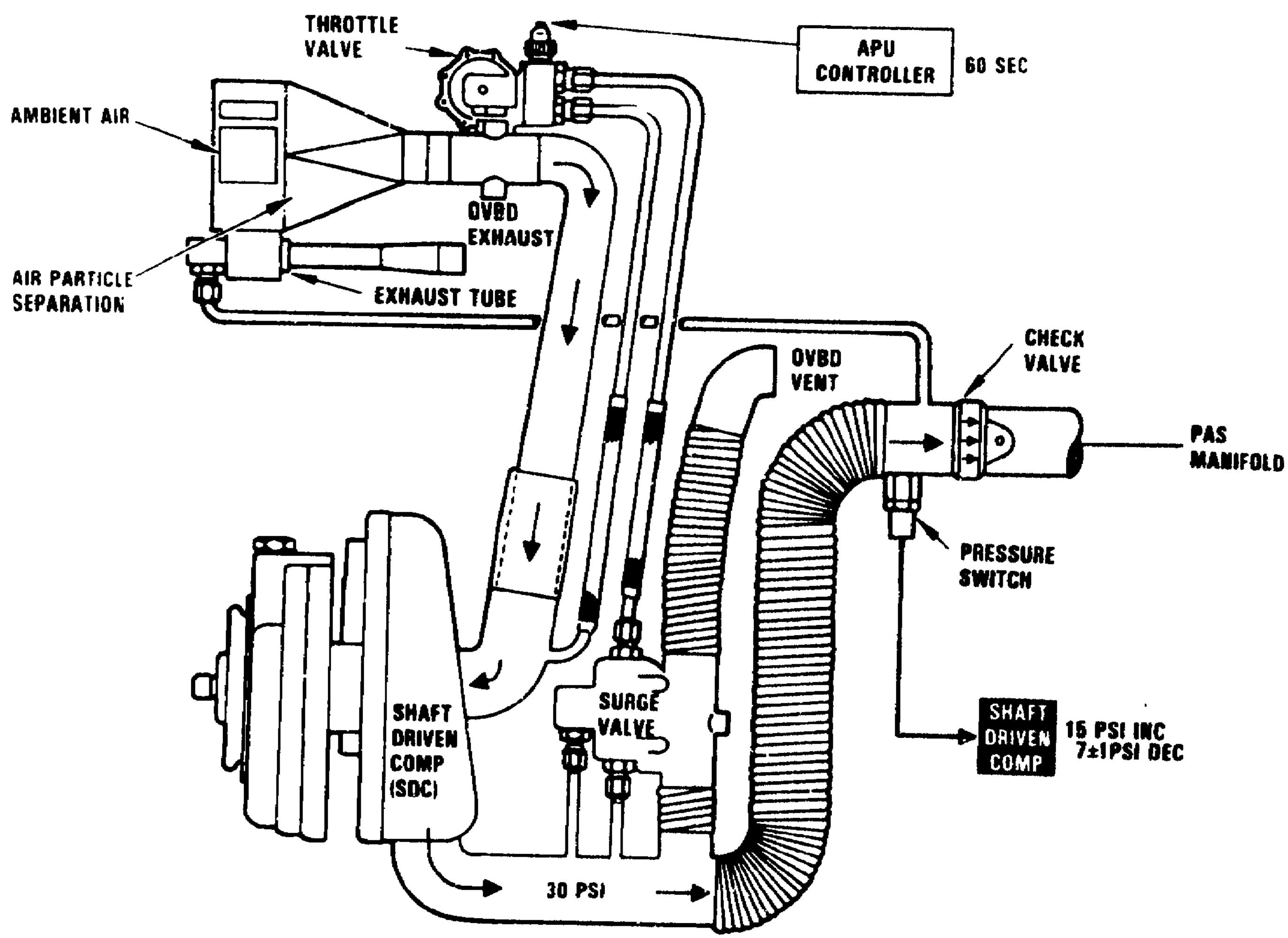


Figure 21. Primary Air Source

and bleed air from the fifth stage compressor of the left engine (fig. 22). The engine bleed air automatically pressurizes the PAS whenever the engine is running and the SCD outlet pressure is less than 10 psi.

ENVIRONMENTAL CONTROL UNIT

32. The environmental control unit (ENCU), located on the left side of the transmission deck, provides cooling, heating, and moisture removal from the air for crew compartment, and provides cooling for the avionics bays.

33. The ENCU is a self-contained air cycle unit made by AiResearch Manufacturing Company (fig. 23). Cooling is accomplished by circulating pressurized air from the PAS through heat exchangers and a turbine to produce cooling without the use of freon gas. The distribution of conditioned air is shown in figure 24.

ELECTRICAL SYSTEM

34. Electrical power to start the APU is provided by either an external source through a recepticle on the right side of the aircraft or from the 24 volt nickel-cadmium battery. Once the APU or main engines are operating, electrical power is supplied by two 115 volt AC, 3 phase, 400 hertz, [illegible] kva generators. For the DC power required, there are two 28 volt DC transformer/rectifiers. Figure 25 shows the locations of the major electrical system components.

ANTI-ICE SYSTEMS

35. Aircraft components protected by anti-ice systems were the engine, engine inlet fairing, nose gearbox fairings, cross shaft fairings, two canopy panels, PNVS turret window, and the TADS turret assembly. The engine anti-ice system, located internally in each engine, provides heated (bleed) air to the swirl vanes, nose splitter, and inlet guide vanes (fig. 26). The engine inlet anti-ice system, located within the forward end of the engine inlet fairing, provides heated (bleed) air to the inlet fairing plenum to prevent the formation of ice (fig. 27). The nose gearbox and cross shaft fairings contain electrical heating blankets. An electrically-heated layer is laminated between the two pieces of glass that make up the lower and center panels of the windscreen (fig. 28). TADS and PNVS components are also electrically heated.

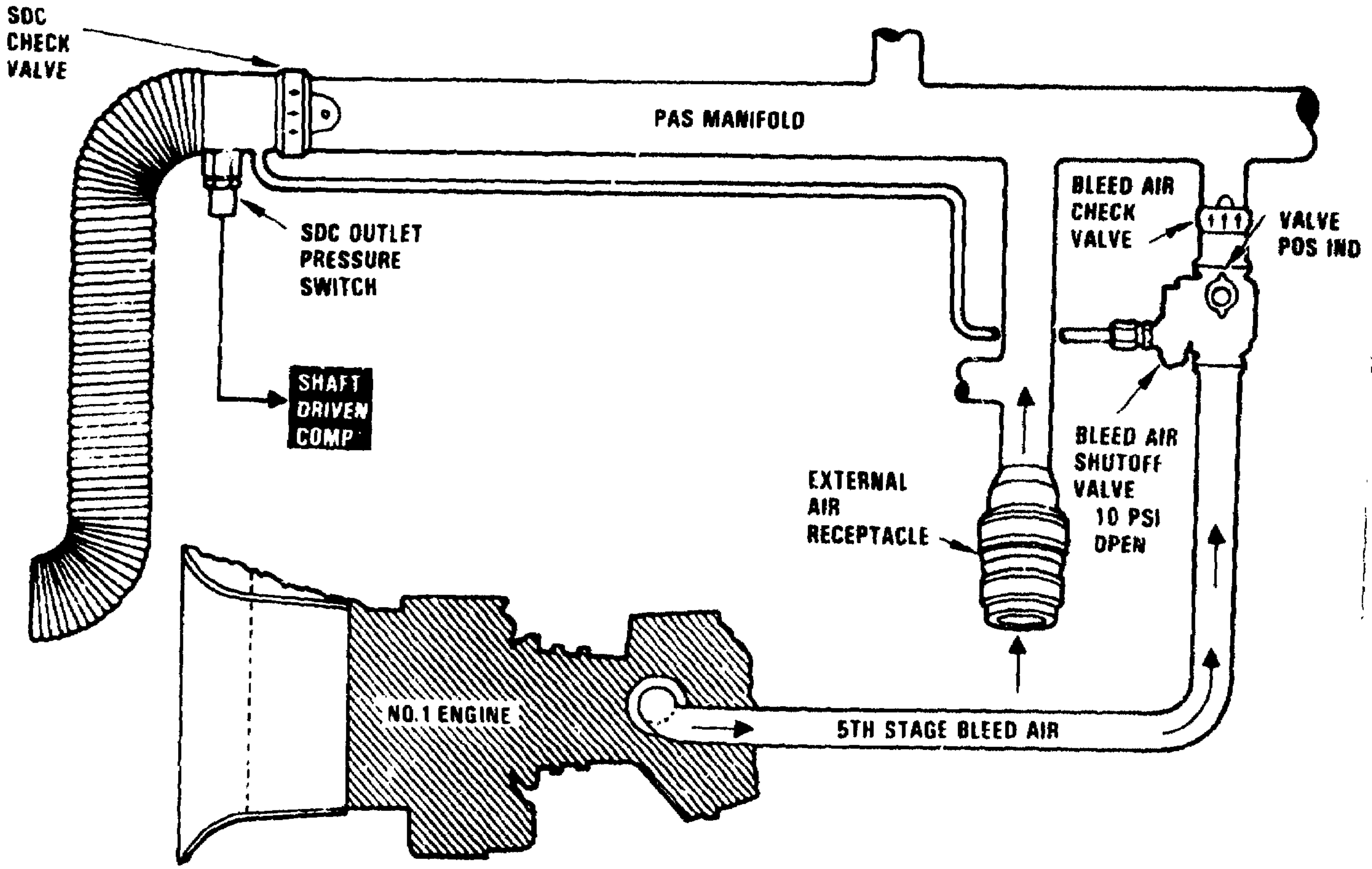


Figure 22. Alternate Air Sources

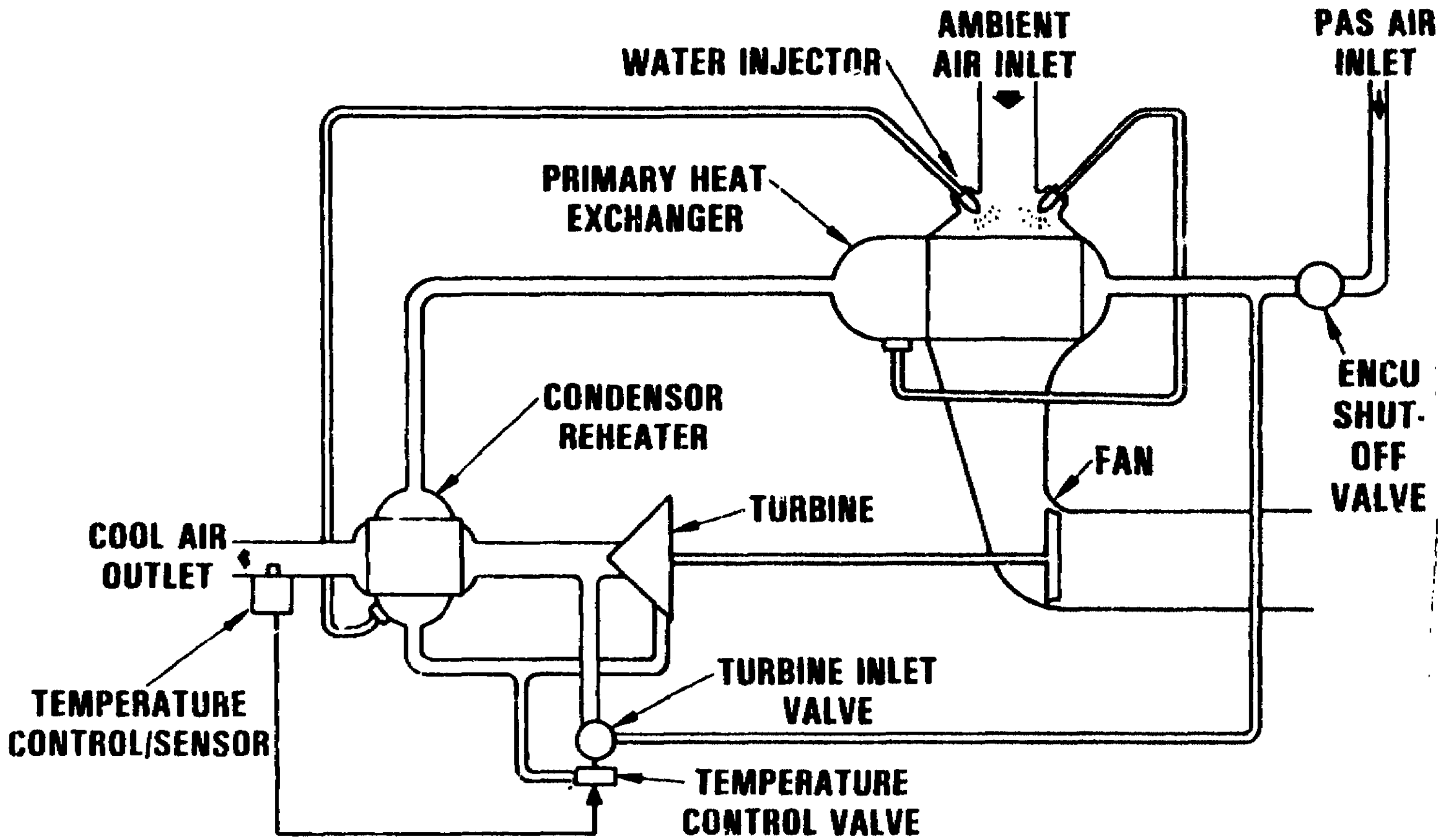


Figure 23. ENCU Operation

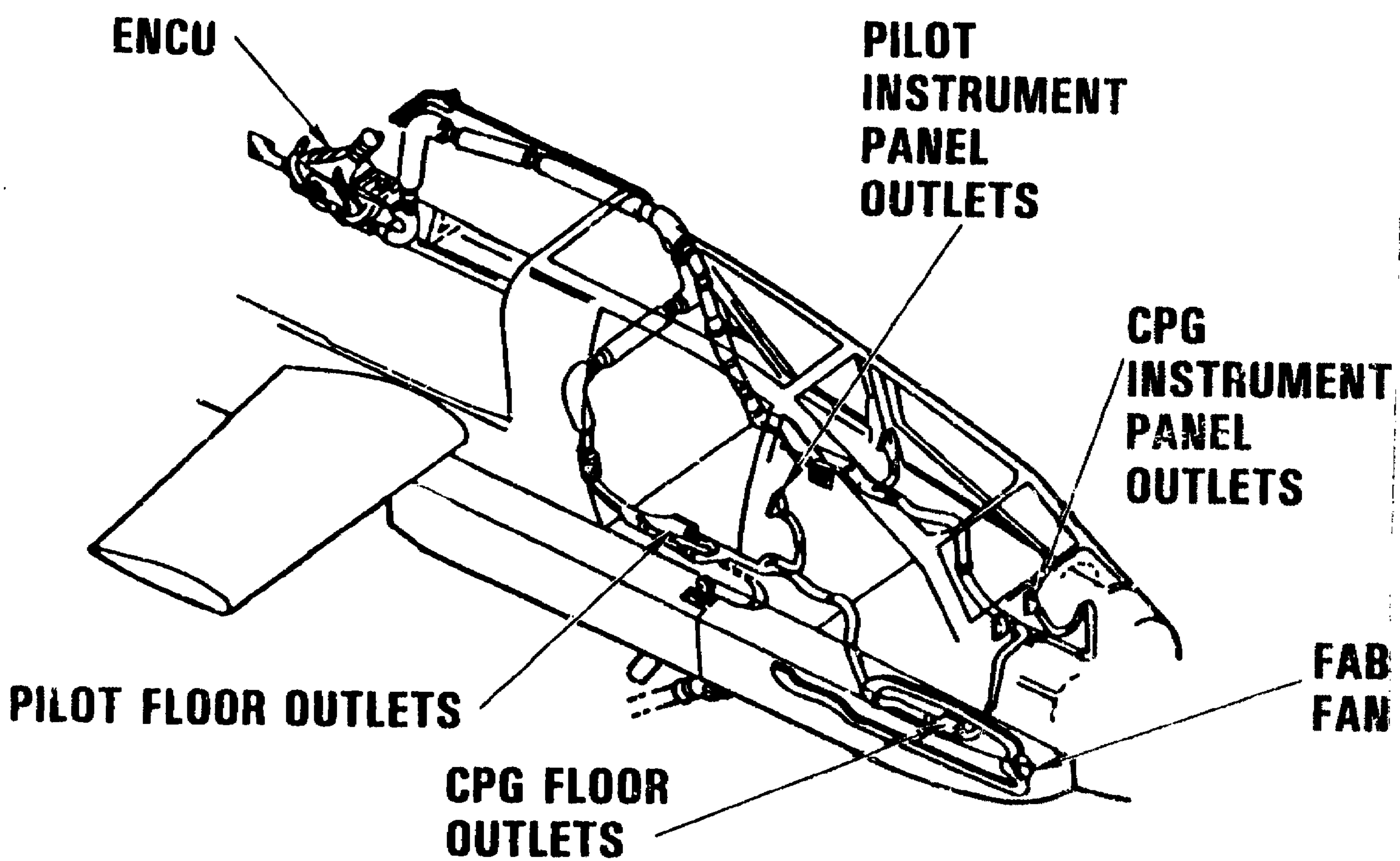


Figure 24. Air Distribution System

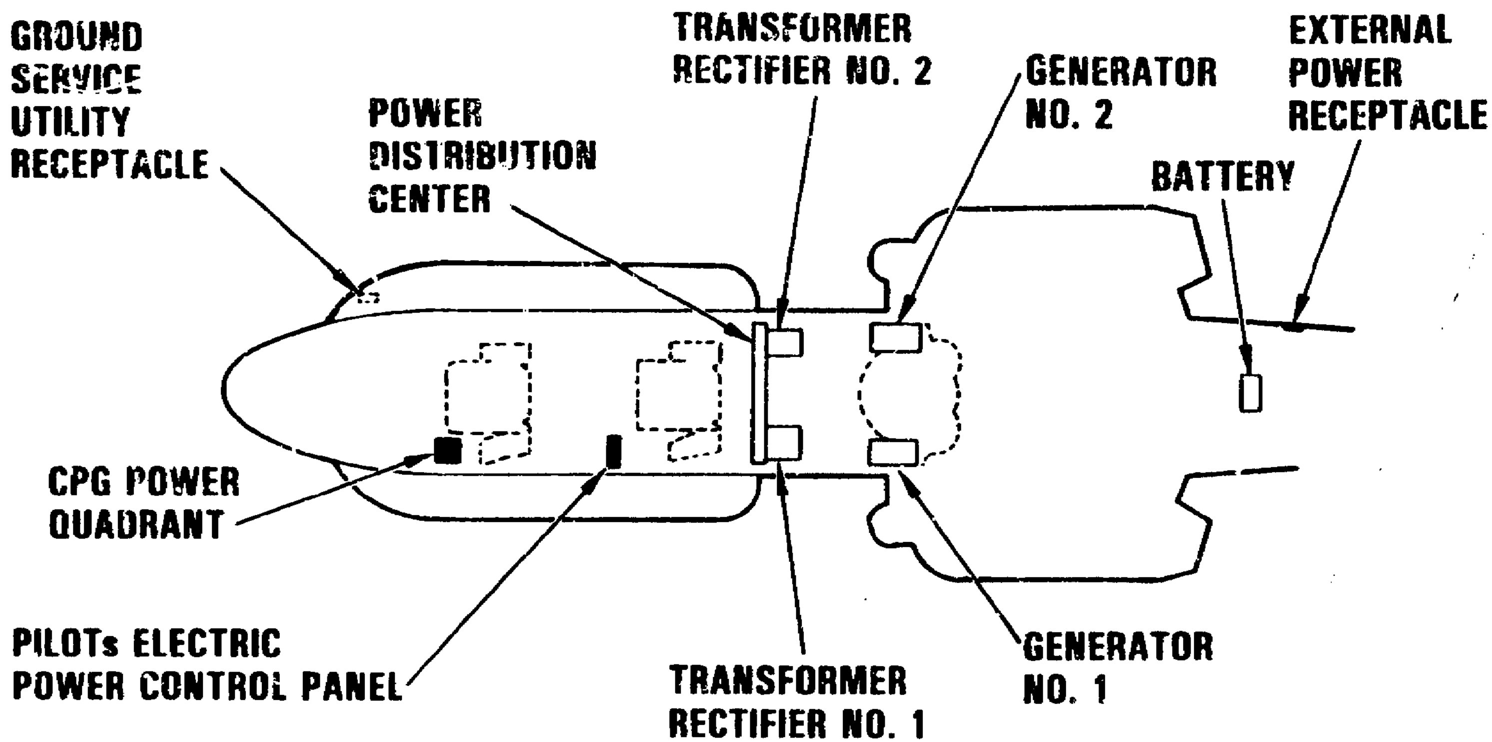


Figure 25. Component Locations

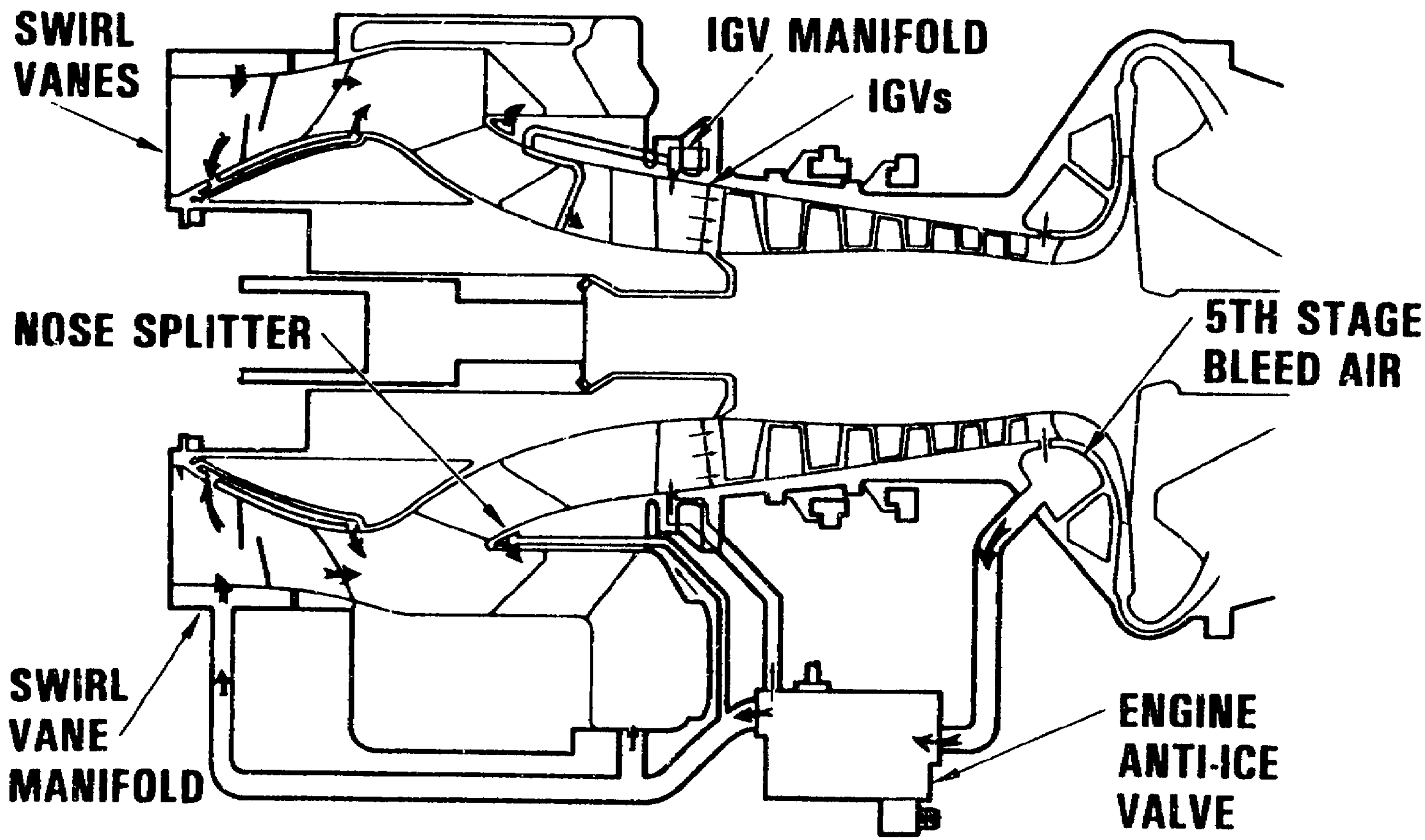


Figure 26. Engine Anti-Ice

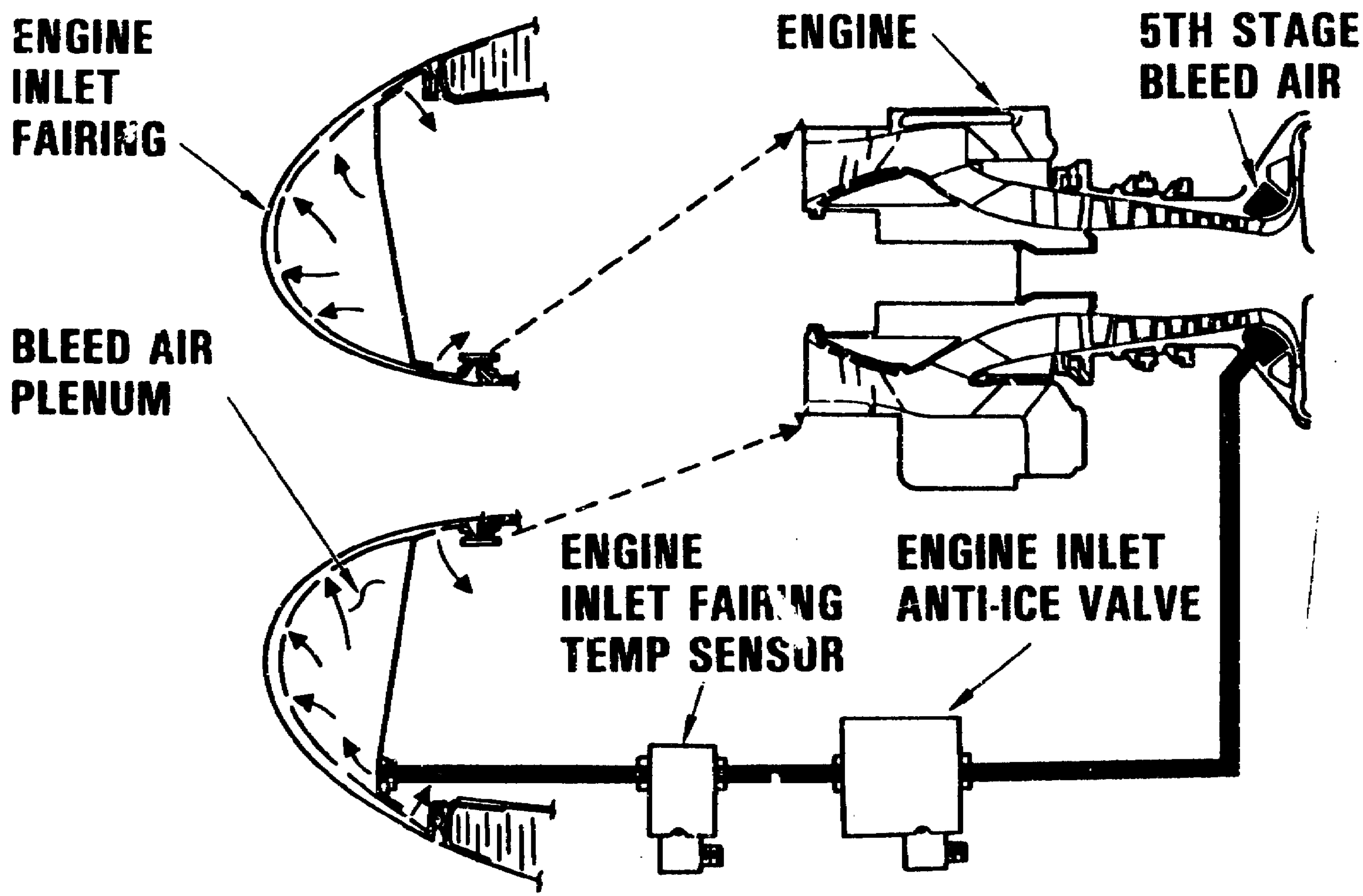


Figure 27. Engine Inlet Anti-Ice

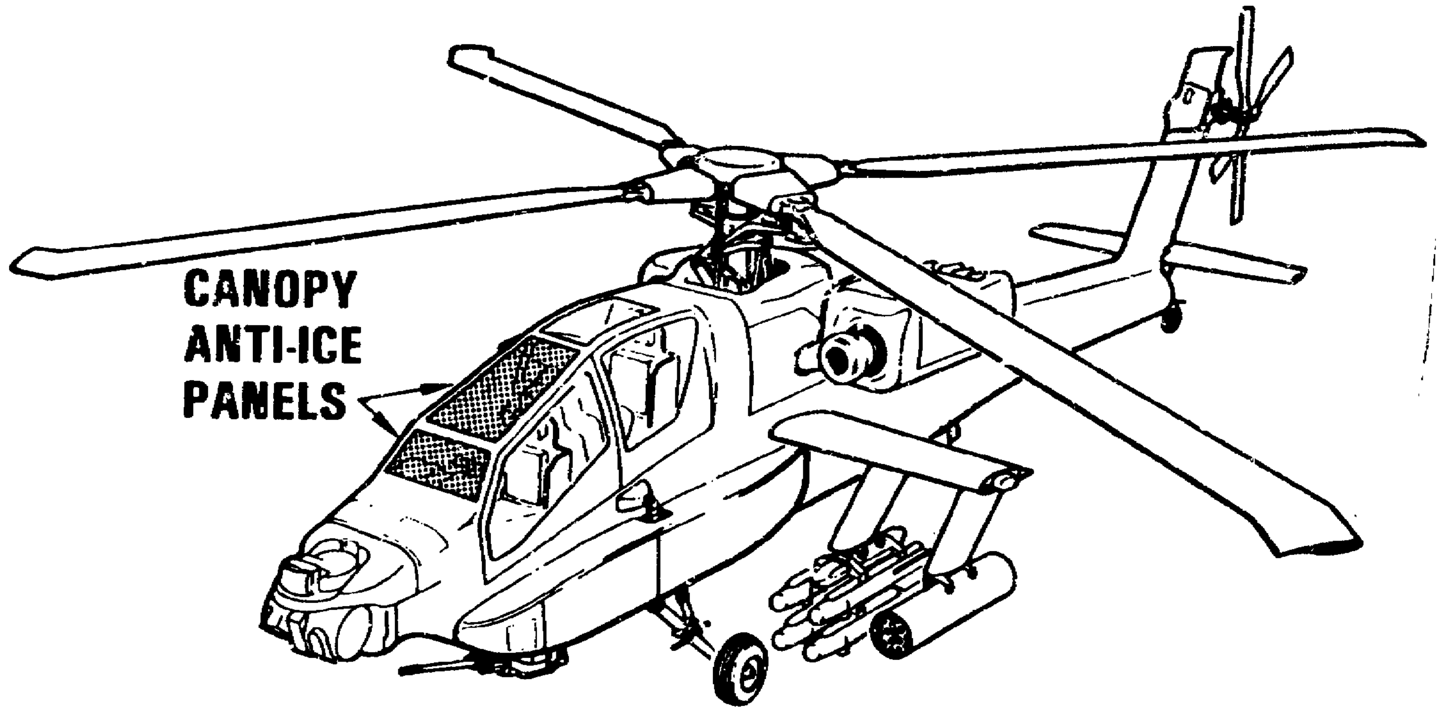


Figure 28. Canopy Anti-Ice Panels

MISSION EQUIPMENT

36. Mission equipment included the 30mm weapon, HELLFIRE missile system, pilot night vision system, and target acquisition/designation system. These systems are described in appendix H.

APPENDIX C. INSTRUMENTATION

1. Aircraft instrumentation was provided, installed, calibrated, and maintained by HHI. The instrumentation used consisted of transducers, signal conditioning, cockpit displays, interface to remote real-time displays and magnetic tape recording. The parameters listed in this appendix were chosen to provide the capability to evaluate problems in the various systems as they occurred during the test.

2. In addition to the standard aircraft instruments, the following parameters were measured and displayed in the cockpit:

Longitudinal control position
Lateral control position
Directional control position
Collective control position
Tail rotor thrust load cell
Time of day
Selectable display of PCM parameters

3. The following parameters were measured and recorded on magnetic tape. The measurement numbers are listed on the figures in appendix E also.

AUXILIARY POWER UNIT

Measurement Number		Type of Parameter	Units
1004	Turbine Speed..................	Speed	Percent
3028	Oil sump.......................	Temperature	DEG C
2096	Oil pump outlet................	Pressure	PSIG
3230	Exhaust gas temperature........	Temperature	DEG C
2095	Fuel pressure..................	Pressure	PSIG

PROPULSION SYSTEM

Left Engine

3139	Engine driven fuel pump........	Temperature	DEG C
2031	Engine driven fuel pump........	Pressure	PSID
3012	Oil (T harness)................	Temperature	DEG C
2056	Oil (T harness)................	Pressure	PSIG
2099	Starter regulator air output...	Pressure	PSIG
3002	Measured gas (TGT 4.5).........	Temperature	DEG C

Measurement Number		Type of Parameter	Units
4020	Bleed air duct after inlet anti-ice valve...............	Temperature	DEG C
3961	Inlet (surface)................	Temperature	DEG C
4023	ECU (surface)..................	Temperature	DEG C
9038	Load demand spindle position...	Position	Degrees
3991	Fuel injector 1:00 (surface)...	Temperature	DEG C
3992	Fuel injector 1:00 (imbedded)..	Temperature	DEG C
3995	Fuel injector 6:00 (surface)...	Temperature	DEG C
3863	Wiring harness fwd of sta 218..	Temperature	DEG C
7008	Gas generator speed (N_G).......	Speed	Percent
7010	Power turbine speed (N_p).......	Speed	Percent
7011	Fuel flow (volumetric).........	Flow	GAL/HR
7002	Fuel Used......................	Totalizer	LB
7013	Torque.........................	Torque	FT-LB
4014	Cross-shaft fairing (surface)..	Temperature	DEG C
3662	Engine nose gearbox (surface)..	Temperature	DEG C

Right Engine

2032	Engine drive fuel pump inlet...	Pressure	PSID
3013	Oil (T harness)................	Temperature	DEG C
2055	Oil (T harness)................	Pressure	PSI
2100	Starter regulator air output...	Pressure	PSI
3003	Measured gas (TGT).............	Temperature	DEG C
3977	Bleed air duct after inlet anti-ice valve...............	Temperature	DEG C
7007	Gas generator speed (N_G).......	Speed	Percent
7009	Power turbine speed (N_P).......	Speed	Percent
7012	Fuel flow (volumetric).........	Flow	LB
7003	Fuel used......................	Totalizer	LB
7014	Torque.........................	Torque	FT-LB

PRESSURIZED AIR SYSTEM

Manifold

3979	PAS air........................	Temperature	DEG C
2123	PAS air........................	Pressure	PSID

ENCU AIR DISTRIBUTION SYSTEM

Measurement Number		Type of Parameter	Units
3135	ENCU outlet....................	Temperature	DEG C
4001	Pilot's floor outlet...........	Temperature	DEG C
4000	Pilot's foot...................	Temperature	DEG C
3999	Pilot's waist..................	Temperature	DEG C
3973	Pilot's head...................	Temperature	DEG C
4002	Pilot's instrument panel.......	Temperature	DEG C
4004	CPG RH vent outlet.............	Temperature	DEG C
4500	CPG foot.......................	Temperature	DEG C
4003	CPG waist......................	Temperature	DEG C
3974	CPG head.......................	Temperature	DEG C
3673	Left forward avionics bay (FAB) at air inlet...........	Temperature	DEG C
3678	Right FAB at air inlet.........	Temperature	DEG C
3692	Aft avionics bay air exhaust (upstream of fan)............	Temperature	DEG C

ELECTRICAL

DC

8078	Battery voltage................	Voltage	Volts
8083	Battery current................	Current	Amps
8109	No. 1 T/R DC voltage...........	Voltage	Volts
8076	No. 1 T/R DC current...........	Current	Amps
8606	Stabilator actuator current System 1....................	Current	Amps
8607	Stabilator actuator current System 2....................	Current	Amps

AC

8107	No. 1 generator frequency	Frequency	Hertz
8081	No. 1 generator AC phase A current.......................	Current	Amps AC
8108	No. 1 primary bus AC phase A current......................	Current	Amps
8082	No. 2 generator AC phase A Current......................	Current	Amps
8064	No. 1 bus AC phase A voltage...	Voltage	Volts
8070	Nose gearbox heater AC phase A current....................	Current	Amps

Measurement Number		Type of Parameter	Units
8071	Windshield AC phase A current..	Current	Amps
8515	Voltage across DS top window-TF110........................	Voltage	Volts
8516	Voltage across DS bottom window - FS111.................	Voltage	Volts
8517	Voltage across NS window-FT112........................	Voltage	Volts
8518	Voltage across PNVS window-PF24.........................	Voltage	Volts
8519	Voltage across DSM Germanium window-TF113................	Voltage	Volts
8520	Voltage across BSM Schott window-TF114.................	Voltage	Volts
8521	Voltage heater supply-TF115....	Voltage	Volts

CONTROL POSITIONS

Flight Controls

9150	Horizontal stabilator incidence angle.......................	Angle	Degrees
9193	Longitudinal control position..	Position	Inches From Fwd
9194	Lateral control position.......	Position	Inches From Left
9195	Directional control position...	Position	Inches From Left
9196	Collective control position....	Position	Inches From Down
9008	Pitch SAS actuator position....	Position	Percent
9009	Roll SAS actuator position.....	Position	Percent
9010	Yaw SAS actuator position......	Position	Percent
9033	Roll actuator position.........	Position	Percent
9034	Yaw actuator position..........	Position	Percent

Measurement Number		Type of Parameter	Units
HYDRAULICS*			
Utility			
4005	Accumulator inlet (between) manifold/handpump and accumulator..................	Temperature	DEG C
2093	Accumulator inlet (between manifold/handpump and and accumulator)............	Pressure	PSIG
4006	Accumulator outlet (between accumulator and APU start motor)......................	Temperature	DEG C
2094	Accumulator outlet (between accumulator and APU start motor)......................	Pressure	PSIG
2036	Pump inlet.....................	Pressure	PSIG
2034	Pump outlet....................	Pressure	PSIG
3030	Heat exchange inlet............	Temperature	DEG C
3032	Heat exchange outlet...........	Temperature	DEG C
4007	Lateral actuator inlet.........	Temperature	DEG C
4008	Lateral actuator outlet........	Temperature	DEG C
4009	Directional actuator outlet (surface)..................	Temperature	DEG C
4011	Directional actuator outlet...	Temperature	DEG C
4010	Directional actuator inlet.....	Temperature	DEG C
4021	Fluid to 30mm gun turret.......	Temperature	DEG C
Primary			
2035	Pump inlet...	Pressure	PSIG
3238	Pump outlet	Temperature	DEG C
2033	Pump outlet....................	Pressure	PSIG
3029	Heat exchanger inlet...........	Temperature	DEG C
3031	Heat exchanger outlet..........	Temperature	DEG C
4012	Directional actuator inlet.....	Temperature	DEG C
2097	Directional actuator inlet.....	Pressure	PSIG
4013	Directional actuator outlet....	Temperature	DEG C

*All hydraulic fluid temperatures were measured with thermocouples bonded to the external surface of the solid hydraulic line except parameter 4011, which is an internal fluid temperature.

Measurement Number		Type of Parameter	Units
2098	Directional actuator outlet....	Pressure	PSIG

DRIVE SYSTEM

Main Transmission

2037	Accessory gearbox oil (right)..	Pressure	PSIG
3114	Oil sump No. 2 (right).........	Temperature	DEG C
3233	No. 2 oil cooler inlet.........	Temperature	DEG C
3234	No. 2 oil cooler outlet........	Temperature	DEG C
3113	Oil sump No. 1 (left)..........	Temperature	DEG C
3231	No. 1 oil cooler inlet.........	Temperature	DEG C
3232	No. 1 oil cooler outlet........	Temperature	DEG C
2005	No. 1 oil system...............	Pressure	PSIG
7001	Main rotor speed...............	Speed	Percent
3018	Intermediate gearbox No. 1 input ball bearing.................	Temperature	DEG C
3027	Tail rotor gearbox No. 5 input ball bearing.................	Temperature	DEG C

Engine

3014	Lt engine nose gearbox oil.....	Temperature	DEG C
2007	Lt engine nose gearbox oil.....	Pressure	PSIG
2008	Rt engine nose gearbox oil.....	Pressure	PSIG

AIRFRAME

3930	Temperature on transparent windows phase A zone.........	Temperature	DEG C
3931	Temperature on transparent windows phase B zone.........	Temperature	DEG C
3932	Temperature on transparent windows phase C zone.........	Temperature	DEG C

TADS/PNVS

1504	PF2 AZ Gimbal torque ampl output turrent support struc........	Torque	IN-LB
1505	PF4 EL Gimbal torque ampl output turrent support struc........	Torque	IN-OZ
4500	TADS inlet air-TTI.............	Temperature	DEG C
4502	TADS turret exit duct air-TTF..	Temperature	DEG C

Measurement Number		Type of Parameter	Units
4507	Temp inside TADS DS top window-TT7..........................	Temperature	DEG C
4508	Temp inside TADS DS top window-TT8..........................	Temperature	DEG C
4509	Temp inside TADS DS bottom window-TT9..................	Temperature	DEG C
4510	Temp inside TADS DS bottom window-TT10.................	Temperature	DEG C
4511	Temp inside TADS NS window-TT11	Temperature	DEG C
4512	Temp inside TADS NS window-TT12	Temperature	DEG C
4513	Temp inside PNVS window-TT13...	Temperature	DEG C
4514	Temp inside PNVS window-TT14...	Temperature	DEG C
4515	Temp inside BSM port side window-TT15.................	Temperature	DEG C
9500	TF3 yaw rig demod output day sensor assy..................	Angle	Millirad
9501	TF4 Pitch rig demod output day sensor assy..................	Angle	Millirad
9502	TF15 Yaw right torque input day sensor assy (ALC/Servo)......	Rate	RAD/Sec
9503	TF14 Pitch rig torque input day sensor assy (ALC/Servo)......	Rate	RAD/Sec
9512	PF3 PNVS elevation tachometer output demodulated..........	Rate	RAD/Sec
9518	TF1 AZ Gimbal tach output TADS turret......................	Rate	RAD/Sec
9519	TF2 El Gimbal tach output TADS turret......................	Rate	RAD/Sec
9523	DF1 AZ tach output PNVS turret AZ support assembly other....	Rate	RAD/Sec
9138	TADS pointing angle AZ data E AD	Angle	Degrees
9129	TADS pointing angle elev data E AD.........................	Angle	Degrees
9128	TADS turret roll rate R FAB....	Rate	Deg/Sec
9137	TADS turret pitch rate R FAB...	Rate	Deg/Sec
9136	TADS turret yaw rate R FAB.....	Rate	Deg/Sec
9131	CPG LOS train..................	Angle	Degrees
9132	CPG LOS elevation..............	Angle	Degrees
9133	Pilot LOS train................	Angle	Degrees
9134	Pilot LOS elevation............	Angle	Degrees
9520	Gun turret AZ error right FAB..	Position Error	Degrees
9521	Gun turret Elev error right FAB	Position Error	Degrees

Measurement Number		Type of Parameter	Units
9135	Gun train slew rate............	Rate	Deg/Sec
9130	Gun elevation slew rate........	Rate	Deg/Sec

MISCELLANEOUS

0001	Time..........................	Time	Hr,min,sec
0002	Event.........................	Marker	Volts
1298	Tail rotor thrust tube.........	Thrust	LB
3001	Total air temperature..........	Temperature	Deg C

APPENDIX D.
TEST TECHNIQUES AND DATA ANALYSIS METHODS

1. The test was conducted in the Climatic Laboratory at Eglin Air Force Base, Florida. The aircraft was operated while restrained to the hangar floor and control movements were applied to simulate flight.Each test run consisted of aircraft preflight inspection, instrumentation inspection, test profile, and postflight inspection. The utility hydraulic accumulator was recharged by manual hand pump operation at least twice at each temperature, when possible.

2. A typical test profile is presented in table 1. The average test lasted approximately 2 hours, including APU operation before main engine start. A crew chief was present with the aircraft during engine starts and the first few minutes of operation. Visual observation of the right side of operating aircraft was possible directly from the control booth. Both sides of the aircraft were monitored by video cameras and recorded on video tape in the control booth. Selected parameters were available on monitors in the control booth.

3. The postflight inspection included taking oil samples from the engines, engine transmissions, main transmission, and the APU. Inspection panels were removed and inspections conducted for damage and leaks. The aircraft mounting fixture was inspected for shifting and loosening of components.

4. Data obtained at 70°F test conditions were considered base-line data, and values of parameters measured at other test conditions were compared to the base-line data to establish the effect of temperature on a system. The profile runs were as similar to each other as possible to produce comparable data.

5. Definitions of deficiencies and shortcomings used during this test are shown below.

Deficiency - A defect or malfunction discovered during the life cycle of an item of equipment that constitutes a safety hazard to personnel; will result in serious damage to the equipment if operation is continued; or indicates improper design or other cause of failure of an item or part, which seriously impairs the equipment's operational capability.

Shortcoming - An imperfection or malfunction occurring during the life cycle of equipment which must be reported and which should be corrected to increase efficiency and to render the equipment completely serviceable. It will not cause an immediate breakdown, jeopardize safe operation, or materially reduce the useability of the material or end product.

Table 1

I. PREFLIGHT INSPECTION

1. Checklist Complete
2. Calibration Checks
3. Accumulator Pressure
4. Battery Connected
5. CRT Pages-Quick look
6. Announce RUN in 30 minutes-Notify Test Advisor
7. Fire Truck on Station

II. PRETEST

Pilot

*1. BATT CHRGR AC CB-OUT
*2. BATT/EXT PWR-EXT PWR
3. Seat-Adjust
4. Body harness-Fasten
5. Helmet-On
*6. Communication-Check
   a. CPG
   b. Maintenance
   c. Fire Guard
   d. Exhaust Plug Operator
   e. Air Makeup
   f. Instrumentation Booth
   g. Data Recorders
   h. Observation Booth
   i. Test Advisor
   j. Test Director
*7. EDGE LT PNL-On
*8. Overhead circuit breakers-As desired IFF CB-OUT
9. Collective lever switches- As desired
10. Auxiliary vent handle-Closed
*11. Utility light-On
12. ANTI-ICE panel switches-Off

Copilot/Gunner

*1. BATT OVRD-NRML
2. Seat-Adjust
3. Body harness-Fasten
4. Helmet-On
*5. Time-Check with Data Recorder
6. Collective lever switches
*7. Utlity light-On
8. Circuit breakers-As desired
*9. INTR LTS-On
10. FUEL panel switches
    a. OVRD-PLT
    b. TRANS-Off
    c. BOOST-Off
    d. TK SEL-NRML
11. ANTI-ICE panel switches
    a. TADS-Off
    b. WSHLD WIPER-PLT
12. AUX panel switches
    a. STBY FAN-Off
    b. ICS-NRML
13. MSL panel switches
    a. TYPE-LASER
    b. MODE-STBY
    c. LOAL-Off
14. Data Entry Keyboard-Off
*15. CANOPY JETTISON pin-Installed

*Denotes deviation or modification to the published checklist.

Table 1 (Cont)

II. PRETEST (continued)

Pilot (continued)

*13. EXT LTS-Off, INTR LTS-ON
14. PWR levers-IDLE detent
15. FUEL panel switches
 a. EXT TK-Off
 b. TRANS-Off
 c. BOOST-Off
 d. TK SEL-NRML
 e. ENG 1-Off
 f. ENG 2-Off
16. ENG START-Off
*17. Gen 1 & 2- Off
18. STORES JETTISON-Off
19. LOAL-Off
20. DASE-Off
21. ENCU-Off
*22. CANOPY JETTISON Pin-Installed
23. FIRE CONTROL panel
 a. MASTER ARM/SAFE switch-Off
 b. Weapons select-Off
 c. SIGHT SEL-STBY
 *d. ACQ SEL-Off
 e. VID SEL-PLT
 f. ACM-Off
 g. PNVS-Off
 h. BRST-Off
24. ENG FIRE PULL-In
25. Flight instruments
 a. Airspeed indicator-Static indication
 b. STBY ATTD IND-Cage
 c. EADI-Off
 *d. Altimeter-55 feet
 e. RAD ALT-Off
 f. Vertical speed indicator
26. Clock-Check and set
27. HARS-Off
28. EMER HYD switch-Off
29. Center console avionics-Off
30. Right console avionics-Off
31. FIRE APU PULL handle-IN
32. APU control switch-Off
33. FIRE TEST switch-Off

Copilot/Gunner (continued)

16. FIRE CONTROL panel switches
 a. Master CPG ARM/SAFE-Off
 b. Weapons Select-Off
 c. SIGHT SEL-STBY
 d. ACQ SEL-FXD
 e. MUX-PRI
 f. BRSIT-Off
 g. LSR MSL CCM-Off
 h. LRF/D CCM-Off
 i. FC SYM GEN-Off
 j. IHADSS-Off
 k. TADS-Off
17. ENG FIRE PULL handles-In
18. ORT switches
 *a. FOV-Wide
 b. WAS-Off
 c. SENSOR SEL-DTV
 d. Tracker PLRT-Auto
 e. LST-Off
 f. ACM-Off
19. Flight instruments
 a. Airspeed indicator-Static indication
 *b. Altimeter-55 feet
20. COMM CONT panel switches-As desired
21. Right console avionics-Off

Table 1 (Cont)

III. BEFORE STARTING APU

Pilot

1. BATT/EXT PWR-BATT
2. BATT CHRGR AC CB-In
3. Master caution & warning-Reset
4. Master caution & warning-PRESS-TO-TEST
5. Fire Detector-Test
6. ENGINE OUT warning-Test

Copilot/Gunner

1. BATT OVRD-NRML
2. EMERG HYD PWR-Off
3. Master caution & warning-Reset
*4. Communication Check-Pilot
*5. Master caution & warning panel-PRESS-TO-TEST, Discharge Check
6. Selectable digital display TEST button-Press

IV. APU START

Pilot

*1. Canopy Door-Closed
*2. Air makeup-Starting APU
*3. Exhaust Duct Plugs-Out
*4. Fire Guard-Posted
*5. Utility Acc Pressure
*6. Data/Video-On
*7. APU-Run 3 sec, then Start, START
8. APU ON light-On 5% N_g
9. Hydraulic Pressure
10. N_g speed -100%
11. GEN 1 & 2-TEST, then GEN
12. ENCU-On
*13. EXT PWR-Disconnect
*14. EXT LTS-NAV BRT

Copilot/Gunner

*1. Canopy door-Closed

V. APU RUN/SYSTEMS CHECK

Pilot

*1. PNVS-On
2. Standby attitude indicator-Uncage
3. EADI-Hov
4. RAD ALT-On

Copilot/Gunner

1. Avionics-On
2. ADS-On
3. FC SYM GEN-On
4. IHADSS-On (announce to pilot)

Table 1 (Cont)

V. APU RUN/SYSTEMS CHECK (continued)

Pilot (continued)

5. HARS control switch-FAST
6. Avionics-On
*7. SHAFT DRIVEN COMP light-Off, 60 sec
8. STABILATOR-Check as follows:
   a. STAB FAIL caution light-Check extinguished
   b. STAB FAIL audio tone-Off
   c. STAB POS DEG indicator-23° to 27°
   d. NOE/APP mode switch NOE/APP
   e. STAB manual control switch-Check full range of stabilator. Note STAB FAIL and master caution lights on and NOE/App switch unlatched.
   f. Reset switch-Press, check STAB FAIL light extinguishes and stabilator returns to 23° to 27°
*9. Park Brake-Set, Check, Release

Copilot/Gunner (continued)

*5. TADS after -25° Time Hack
   a. VID SEL-GRAY SCALE
   b. Adjust brightness and contrast HUD-HDD
   c. VID SEL-TADS
   d. SIGHT SEL-TADS
   e. Slave button: NOTE turret returns from Stow to FWD: NOTE movement rate
   f. Slave button: NOTE TADS goes to MAN
   *g. Exercise thumb force controller: Note rate and freedom of movement
   h. Evaluate all FOVs: Note movement
   *i. Evaluate IAT Off Set
   j. Sensor SEL to DVO: Note movement

Table 1 (Cont)

V. APU RUN/SYSTEMS CHECK (continued)

Pilot (continued)

Copilot/Gunner (continued)

*k. Evaluate optimum focus of AND
l. Sensor SEL to FLIR: Note movement
m. Adjust gain & level for optimum image
n. Evaluate all FOVs
*o. Evaluate IAT Off Set
*p. SENSOR SEL to DTV NFOV
q. With thumb force controller stabilize on a TGT, Evaluate drift

VI. SYSTEM CHECK

Pilot

*1. IFF CM-In (air)
2. IHADSS BRST
   a. CSL lights-On
   b. IHADSS BRST-On
   c. Align HMD reticle with BRU
   d. HMD BRST-Actuate then release
   e. IHADSS BRST-off
   f. CSL lights-As desired
   g. VID SEL-GRAY SCL
   h. Adjust brightness and contrast
   i. VID SEL-PLT
   j. SIGHT SEL-NVS Check image registration and proper turret function.
   k. Adjust symbol brightness, gain level for optimum image
   l. Verify capability to select the various modes of flight symbology.

Copilot/Gunner

*1. IHADSS
   a. CSL lights-On
   b. IHADSS BRST-On
   c. Align HMD reticle with BRU
   d. BRST store switch to store
   e. IHADSS BRST-Off
   f. CSL lights-As desired
   g. Sight SEL to HMD/TADS, Evaluate image registration & proper turret functions
      NOTE: In HMD/TADS mode the slave button is used to couple/decouple the TADS turret from the IHADSS helmet
   h. VID SEL to GRAY SCALE
   i. Adjust brightness and contrast-As desired
   j. VID SEL-TADS
   k. Sensor SEL to FLIR

Table 1 (Cont)

VI. SYSTEM CHECK (continued)

Pilot (continued)

3. Engine instruments-TEST switch to TEST-Check instruments and RELEASE
*4. RADAR ALT-TEST
*5. HARS-OPR, Annound to CPG
*6. Flight Control-Hystersis
   a. Lateral
   b. Directional
*7. DASE-On/Step Input
*8. DASE-Off
*9. Frequency Response
   a. Lateral
   b. Directional
*10. Control 0-100%
*11. IFF CB-Out (ground)
*12. Leak Check-Cowls Closed
*13. DASE-Check Off
14. Exercise T/R (-25° to -50°F)

Copilot/Gunner (continued)

1. FOV SEL to Wide. Adjust symbol brightness gain, and level as necessary of optimum image

*2. TADS BRST
   a. DTV
   (1) SEL to TADS
   (2) Sensor SEL to DTV
   (3) FOV to NFOV
   (4) Tracker PLRT to white
   (5) BRST TADS to TADS
   (6) LSR SEL-On
   (7) PLT/GND OVRD switch-As required
   (8) CPG ARM-ARM
   (9) Laser trigger press Obs tracking gates capture laser spot
   (10) Observe laser spot position with respect to DTV crosshairs; if centered, cease lasing and go to step 2b.
   (11) BRST enable-Up position
   (12) Adjust AZ & EL pots to center laser spot on reticle
   (13) BRST enable-Center position
   (14) Laser trigger-Release

VII. ENGINE START

Pilot

*1. Anti-collision light-RED/Off
2. Area-Clear (Test Advisor)
*3. Air makeup-Starting Engines

Copilot/Gunner

1. a. N_g/TGT-Monitor during engines start
   *b. FLIR
   (1) Sensor SEL-FLIR
   (2) Observe tracking gates Capture BRST cue.

Table 1 (Cont)

VII. ENGINE START (continued)

Pilot (continued)

4. Fire guard-Posted
5. ENG 1 & 2 FUEL switches-On
6. RTR BK-LOCK/Off
*7. First engine
   a. START switch-START
   b. PWR lever-IDLE
   c. NG Monitor
   d. TGT-Monitor
   e. ENG OIL pressure gage-Monitor
   f. Engine isntruments-Check
   g. Caution warning lights-Check
8. ANTI-ICE panel ENG INLET switch-On at -25° & -50° Off
9. RTR BK switch-Off
10. PWR lever-FLY
    NOTE: Do not exceed 68% torque before reaching 90% N_R.
11. Second engine
   a. START switch-START
   b. PWR lever-IDLE
   c. NG-monitor
   d. TGT-Monitor
   e. ENG OIL pressure gage-Monitor
   f. Engine instruments-Check
   g. Caution warning lights-Check
12. PWR lever-FLY
13. N_P & N_R-100%
14. Caution warning lights-Check
*15. Fuel XFR-FWD (Notify Copilot)

Copilot/Gunner (continued)

Observe position of BRST TGT. If centered, proceed to step c(1).
(3) BRST enable-Up position
(4) Adjust AZ & EL POTS to center BRST cue on reticle.
(5) BRST enable-To center position

*(2-ALT)
FLIR Loss of BRST Vector. If IAT will not capture BRST Cue, Re-check IAT polarity is White. If conditions persist:
(1) LASER switch Off
(2) SENSOR Select-FLIR
(3) FOV-N
(4) LT switch-Auto
(5) SENSOR Select-TV
(6) Observe display for White Spot. (If not present FOV to Wide.) If no spot search using TFC.
(7) Use Thumbforce contoller to center crosshairs. On White Spot (NOTE: BRST left & right controllers are reversed.)
(8) FOV-N (If previously Wide)
(9) Engage IAT-Observe IAT Lock-On (after 5 sec, tracking gates will disappear)
(10) If Tracker will not Lock-On, Check for slave mode with the ORT slave button
(11) LT SW-off
(12) SENSOR SEL-FLIR
(13) Continue with Normal FLIR BRST Procedures (step b) Remember: De-select IAT

VII. ENGINE START (continued)

Pilot (continued)

Copilot/Gunner (continued)

*c. DVO
(1) BRST TADS-Off (TADS will go FF)
(2) SENSOR SEL-TV-WFOV
(3) Depress ORT slave button
(4) Find TGT in collimator
(5) SEL-NFOV
(6) IAT TGT
(7) Select DVO
(8) DVO-BRST Enable SW (left side ORT)-Down
(9) Adjust reticle until reticle lines up with TGT (use ORT right side SPIRAL switch)

VIII. ENGINE RUN-UP/SYSTEMS

Pilot

1. Engine Chop Circuit Pilot Check as follows:
   a. Collar clockwise and release
   b. N_p & N_g-Check decreasing
   c. Master caution & warning panel-Reset
   d. PWR levers-IDLE
   e. Collar counter-clockwise, and release ENGINE CHOP extinguish
   f. PWR levers-FLY
   g. N_p & N_R-100%
2. Engine Overspeed Test
   a. ENG 1
   (1) CKT A switch-ENG 1
   (2) CKT B switch-ENG 2
   (3) CKT A & B switches
   b. ENG 2
   (1) CKT A switch-ENG 2
   (2) CKT B switch-ENG 2

Copilot/Gunner

*1. Doppler-Program
   a. Doppler MODE SW-Test Check for GO
   b. MODE SW-UTM
   c. DISPLAY SW-DEST/TGT
   d. DEST DISPLAY SW-H
   e. Check DISPLAY for EJ 47197134 GZ: 16R
   f. DISPLAY SW-SPH/VAR
   g. Check for-CL6 E 001.0
   h. FLY to SWITCH-H
   i. Initialize Doppler
*2. FCC Program
   a. DEK-SP-1
      Recall LAT L
   b. If necessary-Enter
      N 30° 28.5
   c. DEK-TGT
   d. Recall GZ
      G
   e. If necessary-Enter
      GZ 16R

Table 1 (Cont)

VIII. ENGINE RUN-UP/SYSTEMS (continued)

Pilot (continued)

(3) CKT A & B switches
3. First Engine ECU Lock-Out System, Check as follows:
   a. PWR lever to LOCKOUT then retard past FLY
   b. Check N_g decreasing
   c. PWR lever-IDLE then FLY
4. Second Engine ECU Lock-Out System, Check same as step 3 above
5. APU-Off

Copilot/Gunner (continued)

f. Recall SPH
   S
g. If necessary-Enter
   SPH CL6
h. Recall MAG VAR
   M
i. If necessary-Enter
   MV E 01.0
j. Recall ALT
   A
k. If necessary-Enter
   ALT +0055
l. Recall WAYPOINT TARGETS
   R-1,2,3
m. If necessary-Enter
   1. 16R EJ 42557169 A +0085
   2. 16R EJ 43037280 A +0085
   3. 16R EJ 45757281 A +0060
n. DEK-SW-CODE
o. Recall CODES - I
p. DEK-SW-FD/LS-RUN GSTAT
q. DEK-SW-STBY

*3. PLT GND/OVRD SW-As necessary
*4. CPG ARM SW-SAFE
*5. RKT SEL SW-NORM
*6. GUN SEL-NORM
    Check Pilot IFF-OUT
*7. MSL SEL-On
    a. Monitor BIT Time
    b. WAS MSL (Check 'AND' DISPLAY)

IX. BEFORE HOVER

Pilot

1. HIT Check
*2. IFF CM-In (air)

Copilot/Gunner

Table I (Cont)

X. HOVER

Pilot	Copilot/Gunner
1. Controls	*1. TADS TEST ___ (IHADSS) a. SIGHT SEL-TADS b. ACQ SEL-FIXED c. TADS ANTI-ICE SW-On ___ d. FLIR-WFOV e. WAS-GUN f. Look toward FIXED FWD g. ORT SLAVE button Depress h. SIGHT SELECT- HMD/TADS i. From FIXED FWD Look Left 90°-MAX Head movement Right Toward FWD ___ j. Look Right 90°-MAX Head movement Left toward FWD ___ k. Look Down 60°-MAX Head movement Up toward FIXED FWD ___ l. Look up 11°-MAX Head movement Down toward FIXED FWD ___ m. At the FIXED FWD position-De-slave TADS n. Sight SEL TADS o. De-WAS GUN p. TADS ANTI-ICE switch-Off
*2. Search Light-Operate	*2. TADS TEST (Thumb Force Controlled) a. WAS GUN ___ b. FLIR-WFOV c. Use Normal Slew with the thumb force to 90° left (initial) d. Check MAX Slew Rates: FLIR WFOV (R) ___ MFOV (LR) NFOV (R) TV WFOV (L) ___ NFOV (R) DVO WFOV (L) ___ NFOV (R) e. TADS-FIXED FWD

Table 1 (Cont)

X. HOVER (continued)

Pilot (continued)

Copilot/Gunner (continued)

*3. Pylon Articulation TEST
 a. Rockets-NORMAL
 b. Enter '0' Range
 c. WAS-Rockets
 d. Slew TADS Elevation & Depression
 e. Check pylons for movement

XI. TAKE-OFF

Pilot

1. Controls
*2. Boost Pump-Check
*3. Fuel TRANS-OFF (Notify CPG)
4. XFEED-OPEN

Copilot/Gunner

XII. CLIMB

Pilot

1. Controls

Copilot/Gunner

XIII. CRUISE

Pilot

1. Controls
*2. Blade De-Ice-EVAL
*3. Generator failures in De-Ice Cycle each -25° only
*4. ECU LOCKOUT
*5. DeFog-EVAL
6. XFEED-NRML (Notify CPG)

Copilot/Gunner

XIV. POWER DESCENT

Pilot

1. Controls

Copilot/Gunner

Table I (Cont)

XV. ENGINE FAILURE

Pilot	Copilot/Gunner
1. Controls	*1. ECL #2-ENG IDLE *2. TADS TEST-Repeat TADS TEST (Thumb force controled) page 17.

XVI. AUTOROTATION

Pilot	Copilot/Gunner
1. Controls	

XVII. POWER RECOVERY

Pilot	Copilot/Gunner
1. Controls	*1. TADS-WAYPCINT TEST a. Update LD"S b. SLAVE TADS to: TGT 1 ________ TGT 2 ________ TGT 3 ________ *2. TADS Repeat TADS TEST (IHADSS) page 16. *3. PLT: Using NVS take control of the TADS, Check for control of the TADS, Check for control of gain, level & PC 16 SW *4. CPG: Using NVS take control of the PNVS, Check control of PNVS turret, Check control of gain & level & ACM *5. PLT or CPG: Conduct PNVS Slew rate tests azimuth and elevation.

Table 1 (Cont)

XVII. ENGINE SHUTDOWN

Pilot

1. Engine Cool down
*2. IFF CB-Out (ground)
3. Weapons Systems-Secure as follows:
   a. SIGHT SEL-STBY
   b. ACQ SEL-OFF
   c. VID SEL-PLT
   d. ACM-OFF
   e. PNVS-OFF
   f. WEAPONS SEL-OFF
   g. MASTER ARM/SAFE-OFF
*4. Air Makeup-Starting APU
5. APU Control Switch-RUN START, then release
6. APU N_g-Monitor
7. Engine N_g-Monitor
8. STBY ATTD IND-Cage
9. EADI-OFF
10. RAD ALT-OFF
11. HARS-OFF
*12. SDC Light-Out
*13. Air Makeup-Engines Stop
14. PWR levers-OFF
*15. ENG #1-Restart after ___ min
16. ENG #2-PWR lever OFF
17. FUEL Panel switches-As follows:
   a. EXT TK Switch-OFF
   b. TRANS Switch-OFF
   c. BOOST Switch-OFF
   d. XFEED Switch-NRML
   e. ENG 1 Switch-OFF
   f. ENG 2 Switch-OFF
18. TGT-Monitor
19. RTR BK Switch-BRAKE, below 50% N_R
20. Avionics-OFF
21. RTR BK Switch-OFF when Rotors stopped.
22. Avionics-OFF
*23. Battery Charge
24. Light Switches-OFF
*25. EXT PWR-Connected

Copilot/Gunner

*1. TADS TEST-Check BRST Retention (on APU Power) After Rotors stopped.
*2. Laser Spot TKR Test-After Rotors stopped.
   a. Auto Search
*3. Missile Test (pg. 24 & __) after Rotors stopped.
*4. XM-230E1, 30mm Gun System Evaluation Procedures
   a. MASTER/CPG ARM to ARM
   b. Track target with selected sight (see flight card)
   c. WAS-GUN
   d. Weapons trigger-Press Slew Gun ________ to limits per flight card.
   e. Cycle 20 RDS 30mm
5. LST-OFF
6. TRACKER PLT-AUTO
*7. VID SEL-TADS
8. SENSOR SEL-DTV
9. IHADSS-OFF
*10. FOV SEL-WIDE
11. SIGHT SEL-STBY
12. TADS-OFF
13. IHADSS-OFF
14. FCC GEN-OFF
15. Weapons SEL-OFF
16. Master CPG ARM/SAFE-OFF
17. PLT/GND OVRD-OFF
18. ADS-OFF
19. Avionics-OFF

Table 1 (Cont)

XVII. ENGINE SHUTDOWN (continued)

Pilot (continued)	Copilot/Gunner (continued)
*26. EXT PWR Switch-EXT PWR	
27. ECS-OFF	
28. GEN-OFF	
29. APU-OFF	
*30. Data/Video-OFF	*20. Data/Video-OFF
*31. Fuel	
32. BATT/EXT PWR-OFF	

AFTER ENGINE SHUTDOWN (APU-RUN)

Copilot/Gunner

*1. Point Mode-LOBL
   a. UPR/LWR Chan Code As desired
   b. UPR/LWR Chan Qty As desired
   c. MSL Mode-NORM
   d. Chan SEL-Establish priority Chan
   e. Observe AND for MSL Selection, and ready status
   f. Observe AND or high action display for proper MSL track status
   g. MSL WAS ________
   h. WPNS Trigger-Press and Release ________
   i. If LOBL not possible conduct LOAL sim. launch

*2. MSL System Shutdown Procedures
   a. MSL Mode-STBY
   b. LOAL-OFF
   c. Chan SEL-Actuate either direction
   d. MSL SEL-OFF

Check on Sensors on TGT

APPENDIX E. TEST DATA

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FIGURE 1

APU START CHARACTERISTICS

APU S/N P113

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES:
1. APU SERVICED WITH MIL-L-23699C OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID
3. JP-5 FUEL UTILIZED
4. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION UNRELIABLE

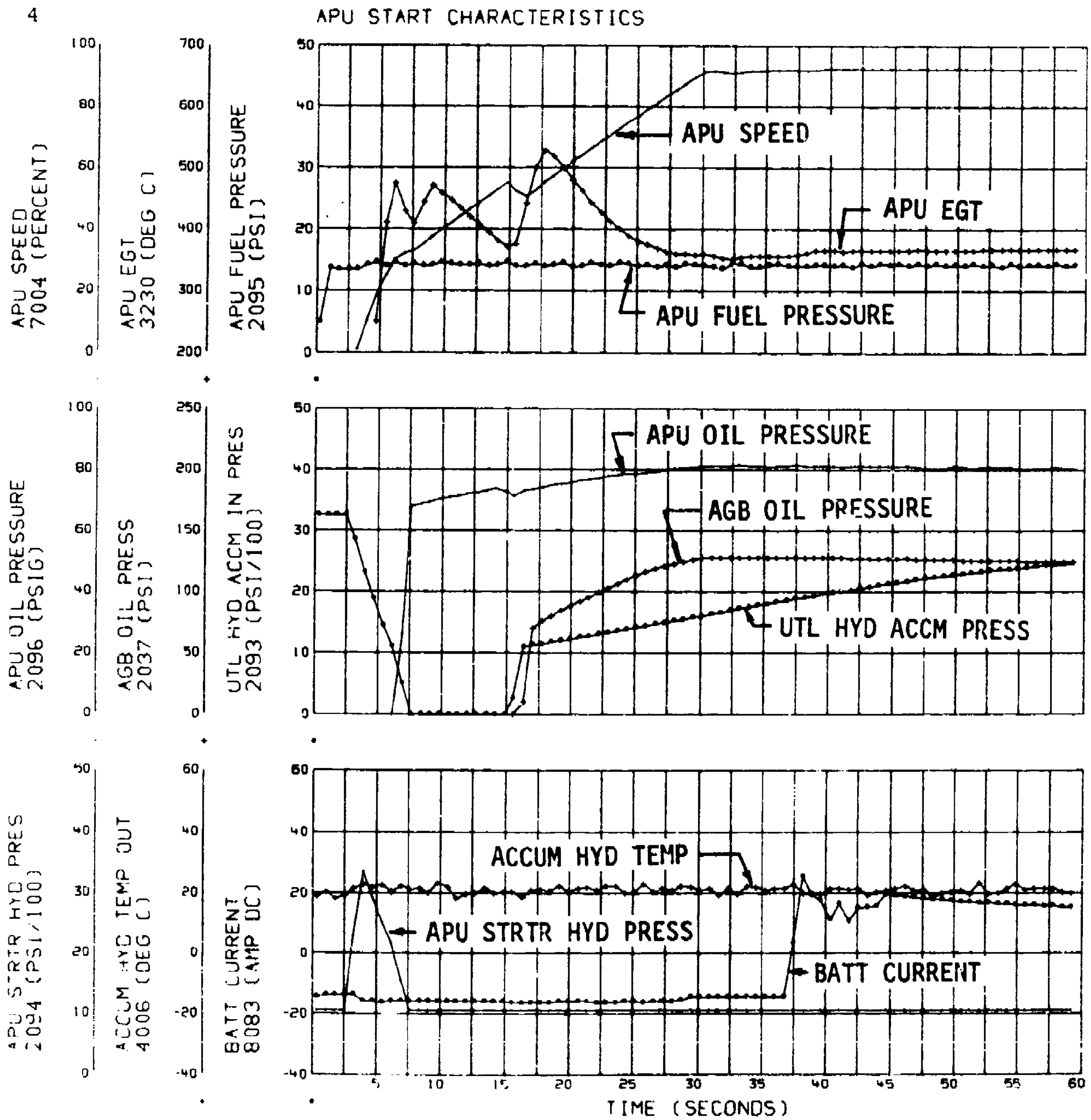


FIGURE 2

APU START CHARACTERISTICS

APU S/N P113

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:

1. APU SERVICED WITH MIL-L-23699C OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID
3. JP-5 FUEL UTILIZED
4. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION UNRELIABLE
5. APU SPEED INSTRUMENTATION READS APPROXIMATELY 25% LOW

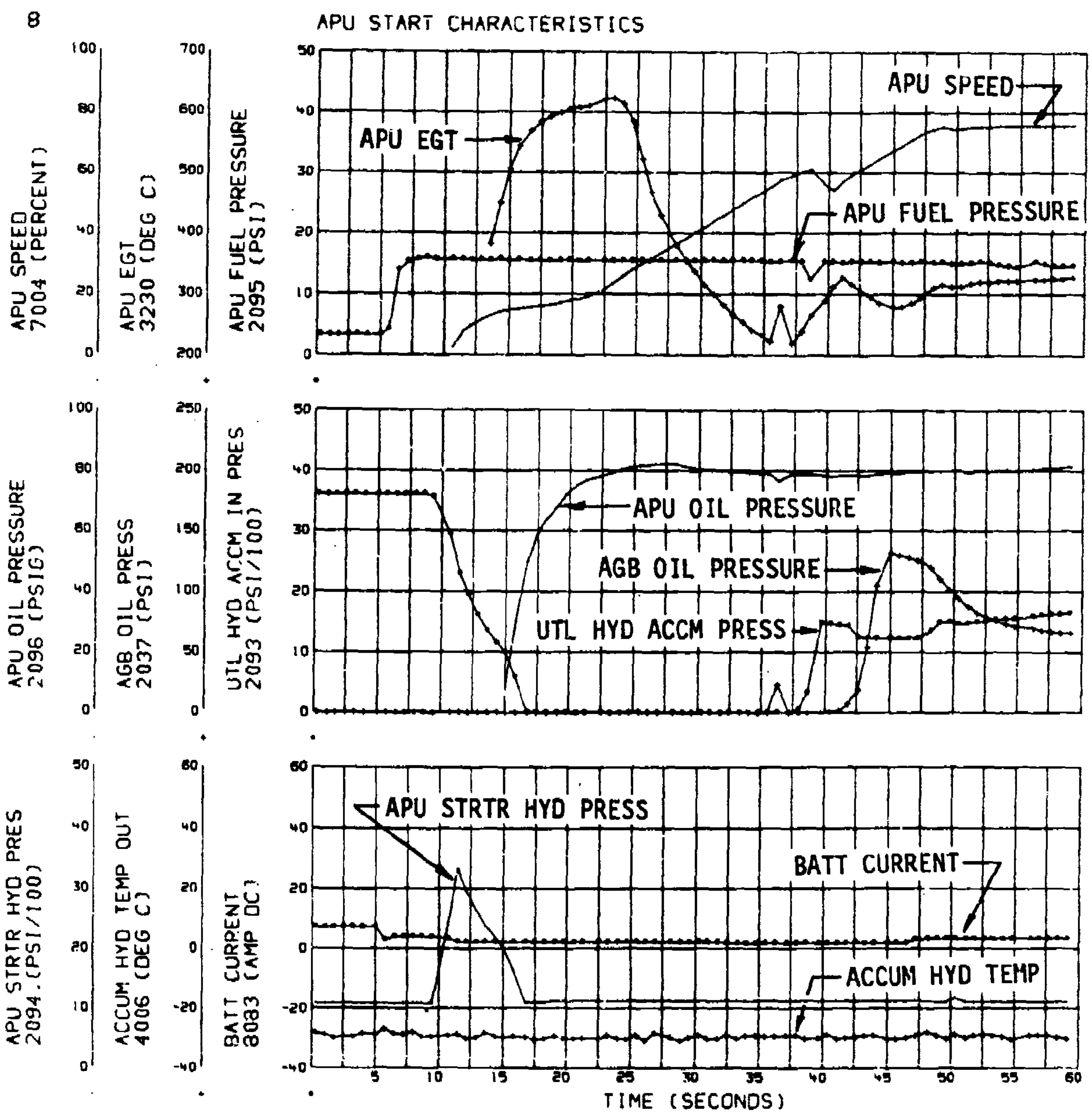


FIGURE 3
APU START CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION FAILED

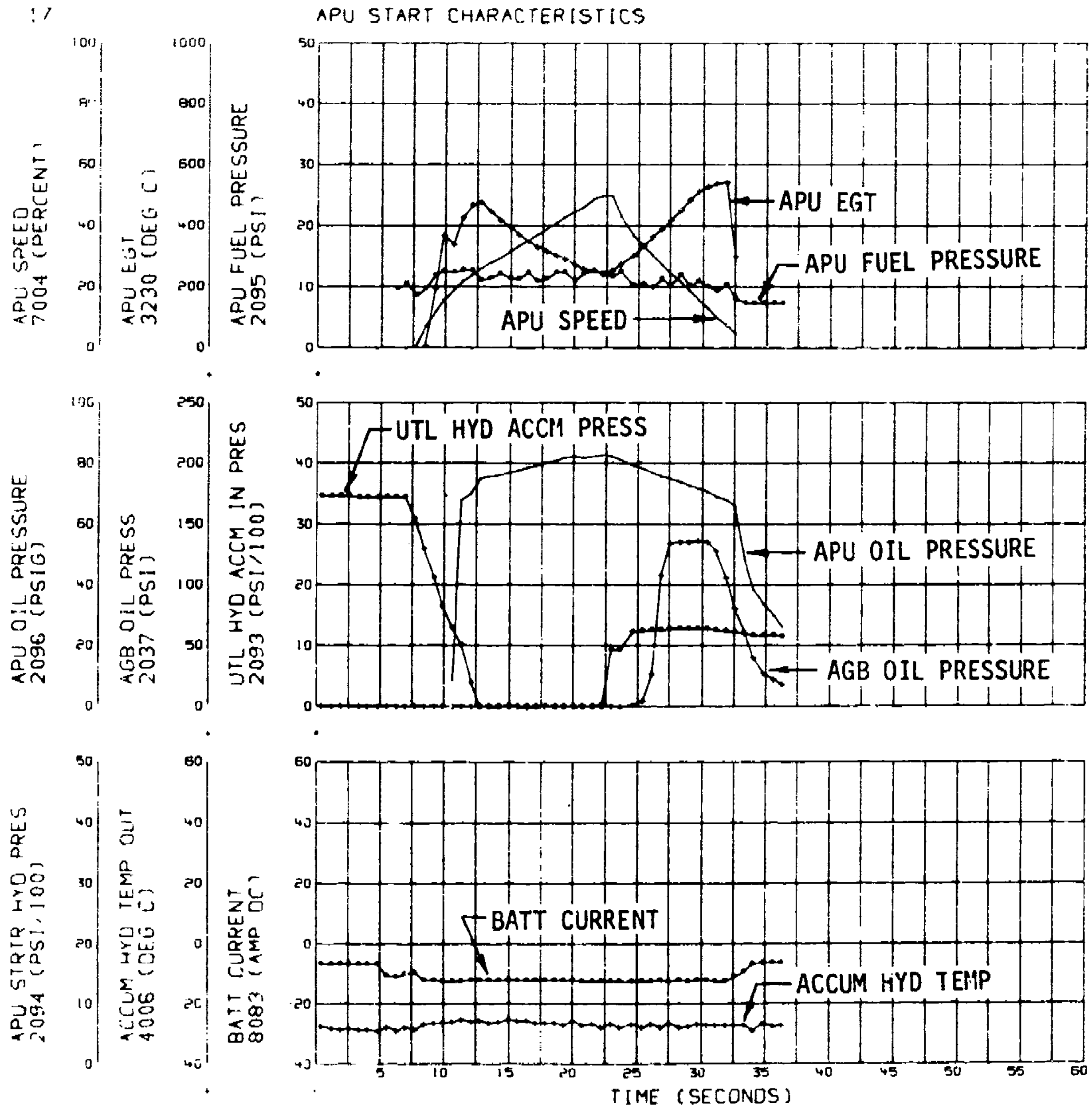


FIGURE 4
APU START CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION FAILED
5. APU SPEED INSTRUMENTATION READS APPROXIMATELY 25% LOW
6. APU CLUTCH ENGAGED AT 90% APU SPEED

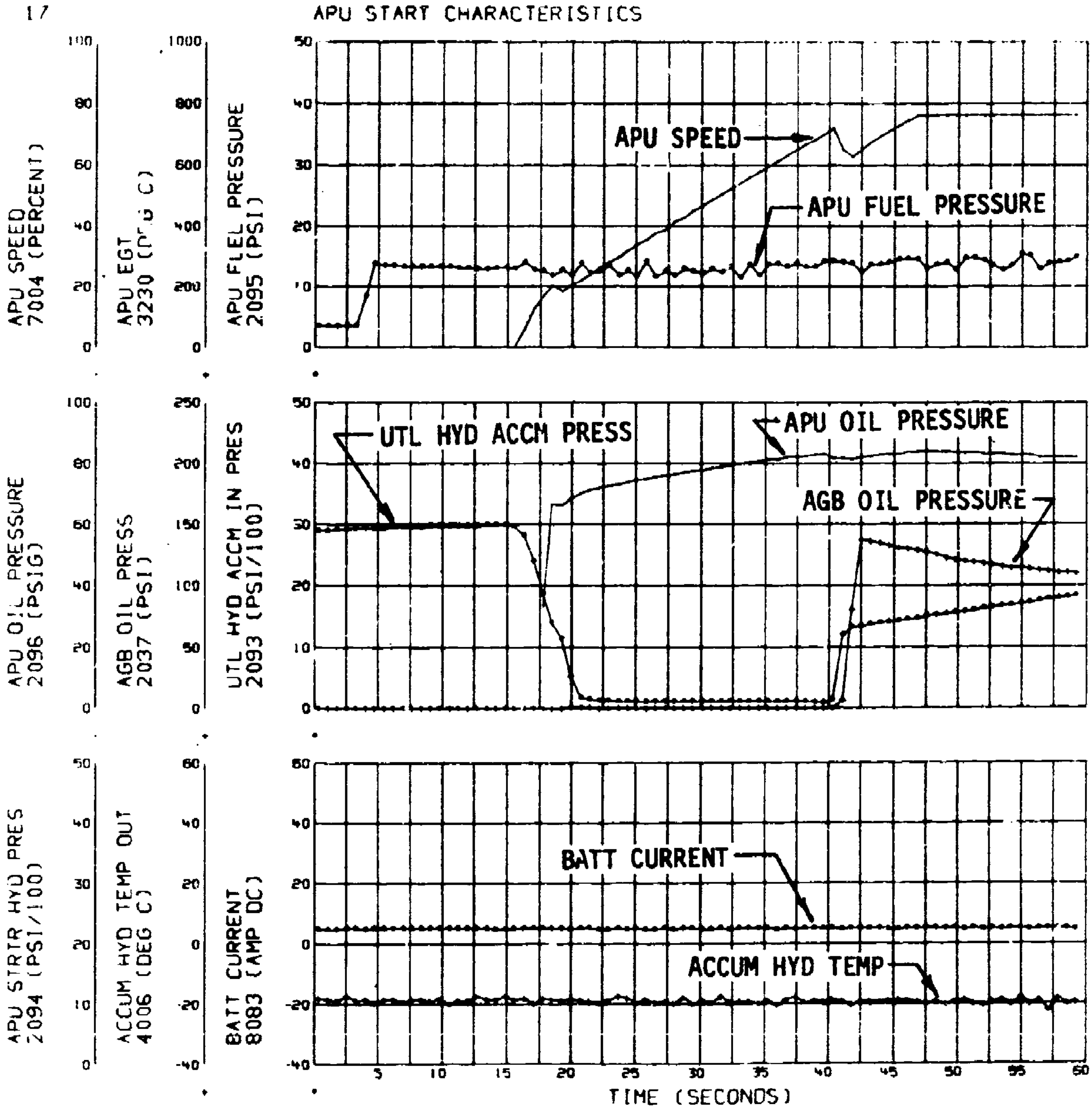


FIGURE 5
APU START CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. ACCESSORY GEARBOX CLUTCH ENGAGED, THEN FAILED
5. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION UNRELIABLE
6. BATTERY CURRENT INSTRUMENTATION FAILED

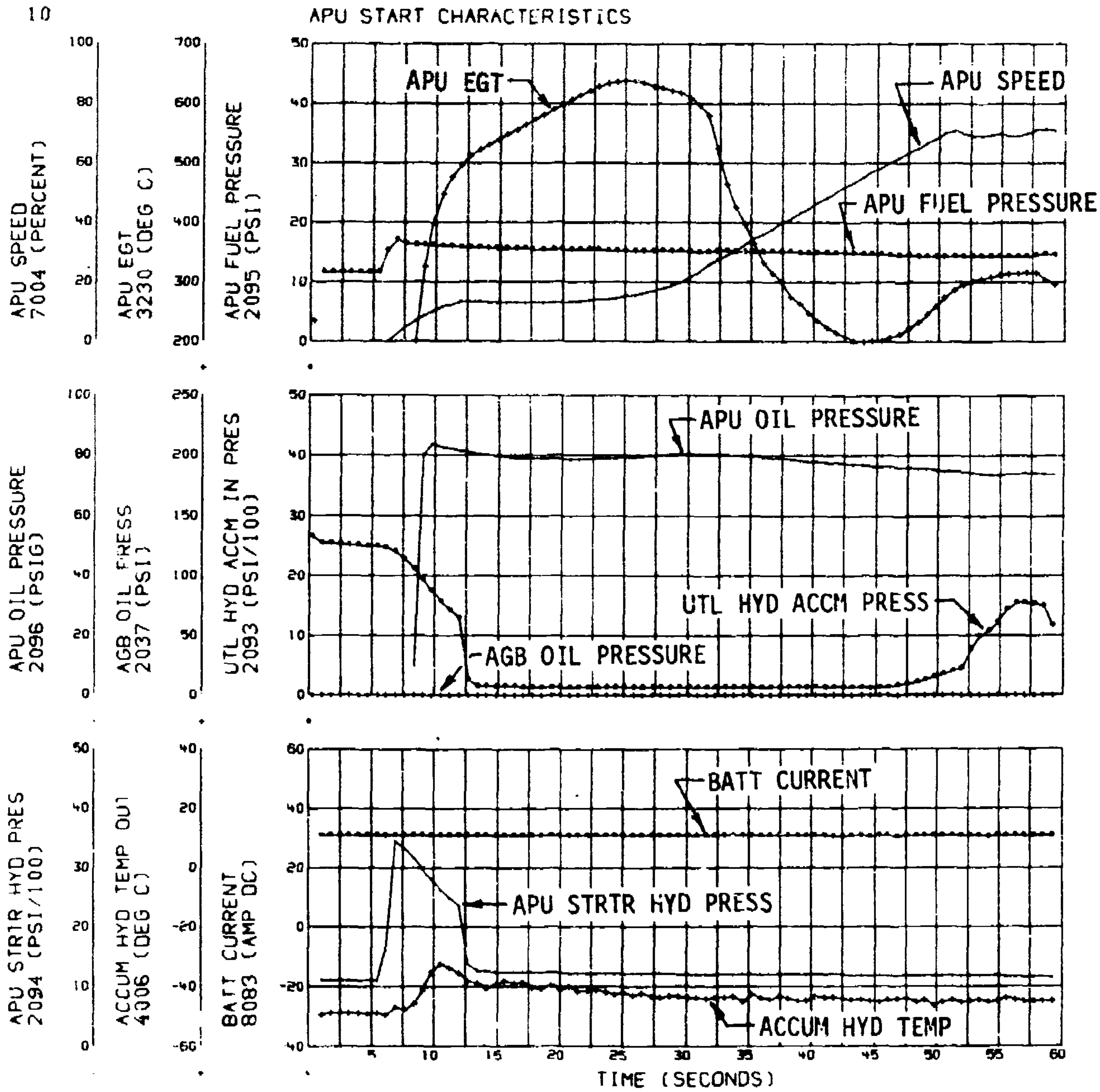


FIGURE 6
APU START CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. BATTERY CURRENT INSTRUMENTATION UNRELIABLE
5. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION UNRELIABLE

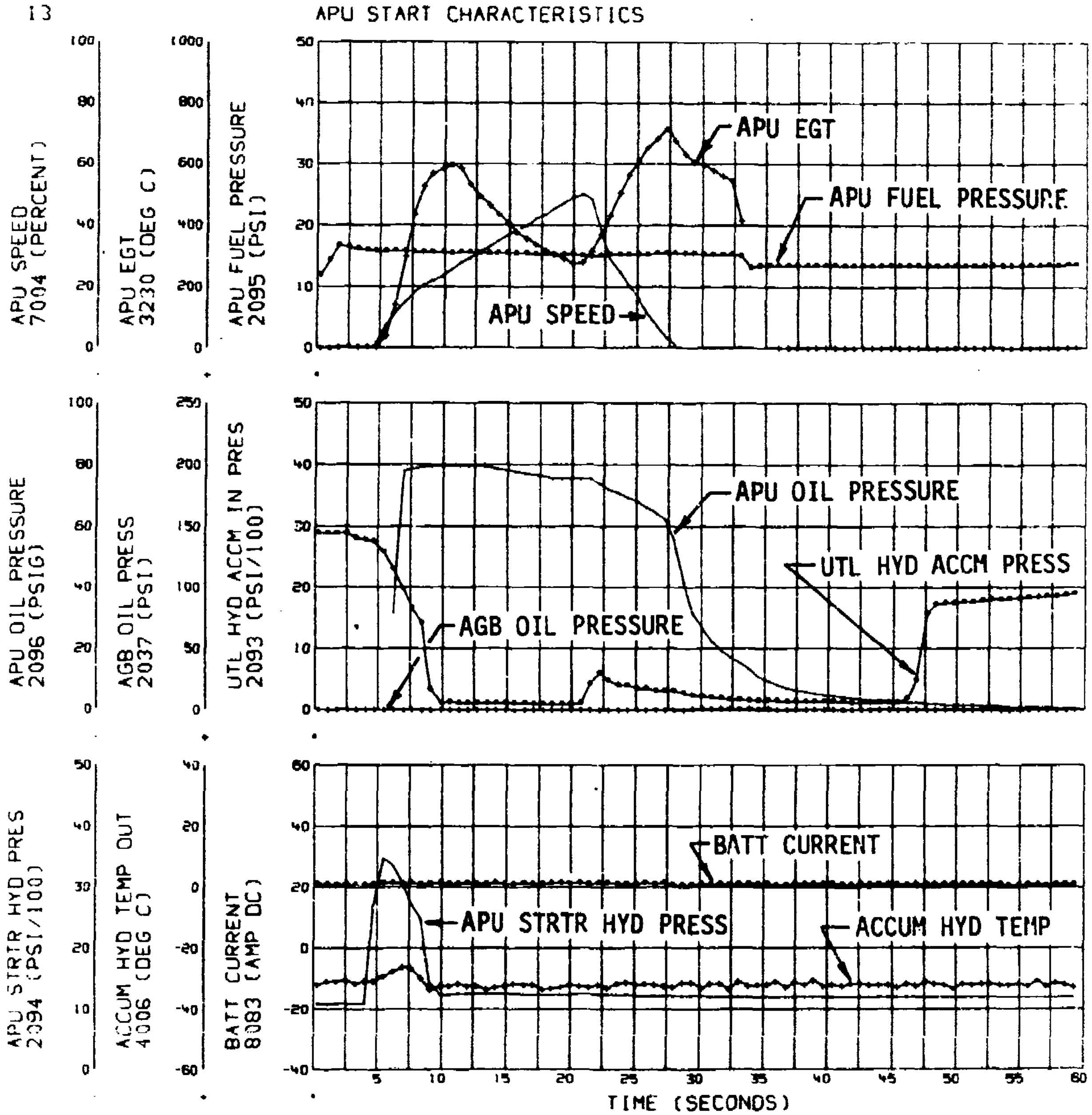


FIGURE 7

APU START CHARACTERISTICS

APU S/N P113

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:

1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. BATTERY CURRENT INSTRUMENTATION UNRELIABLE
5. APU STARTER HYDRAULIC PRESSURE INSTRUMENTATION UNRELIABLE

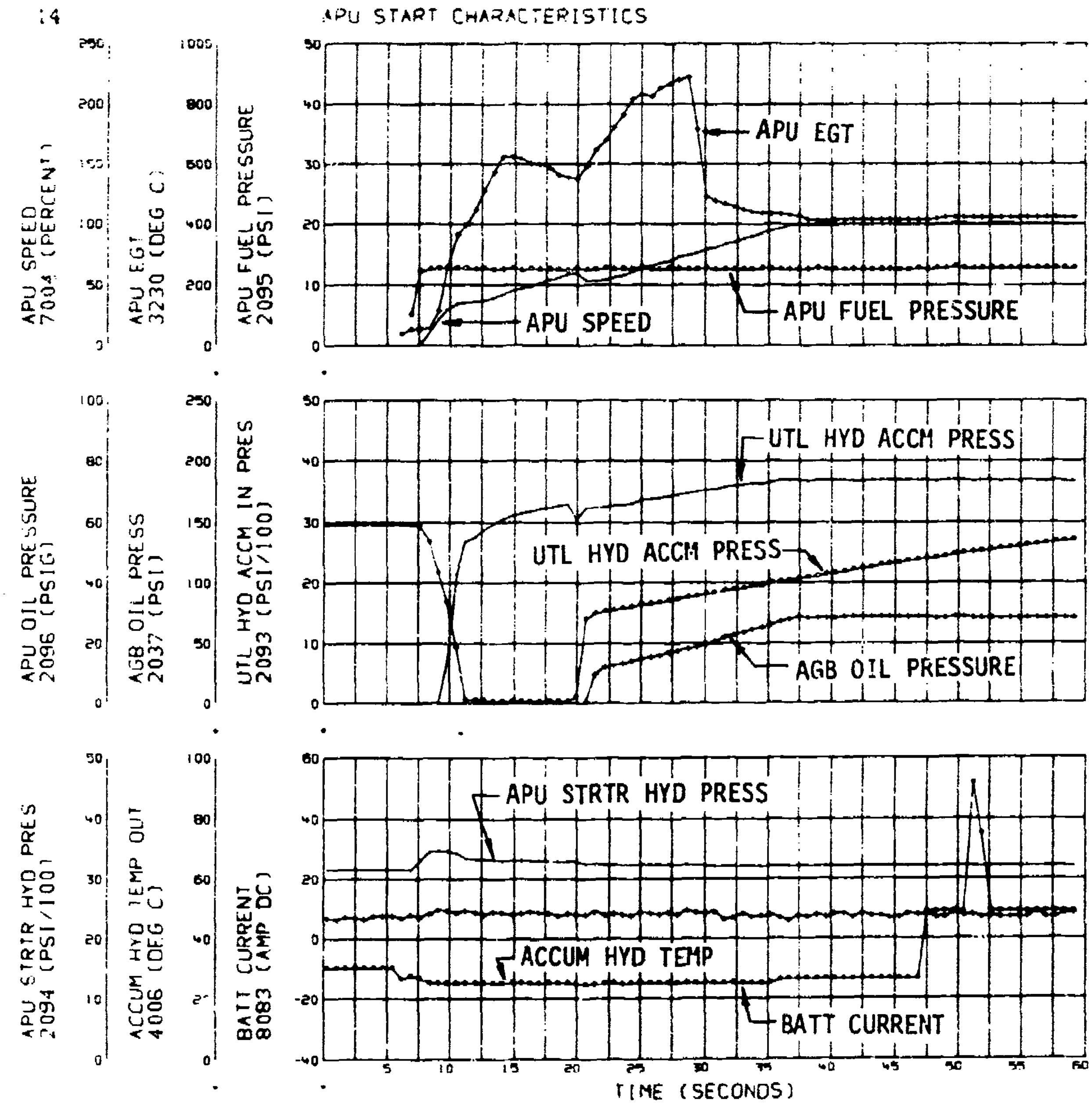


FIGURE 8
APU START CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE $0^{o}F$

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED

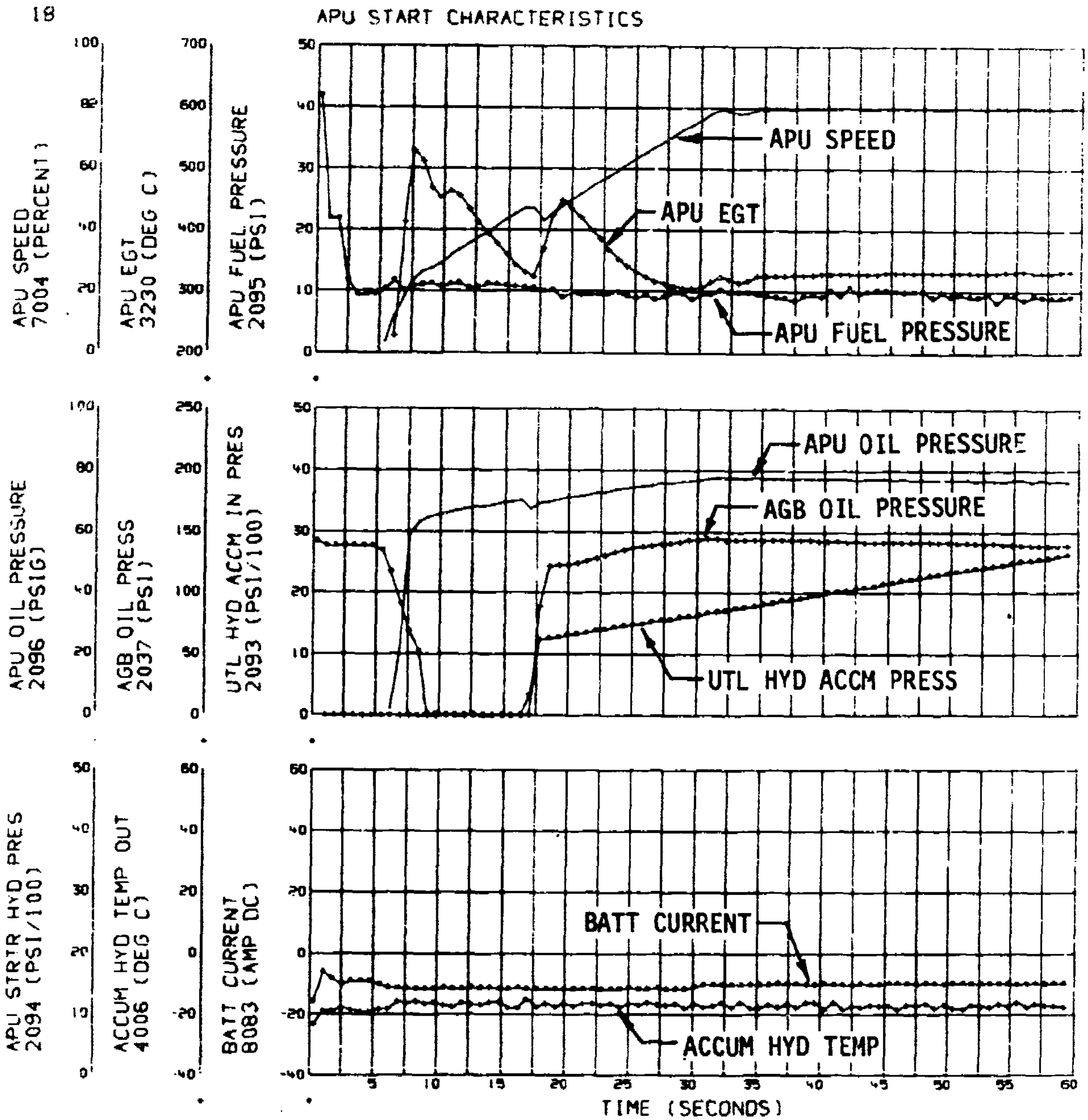


FIGURE 9
APU WARM-UP/RUN CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES:
1. APU SERVICED WITH MIL-L-23699C OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID
3. JP-5 FUEL UTILIZED

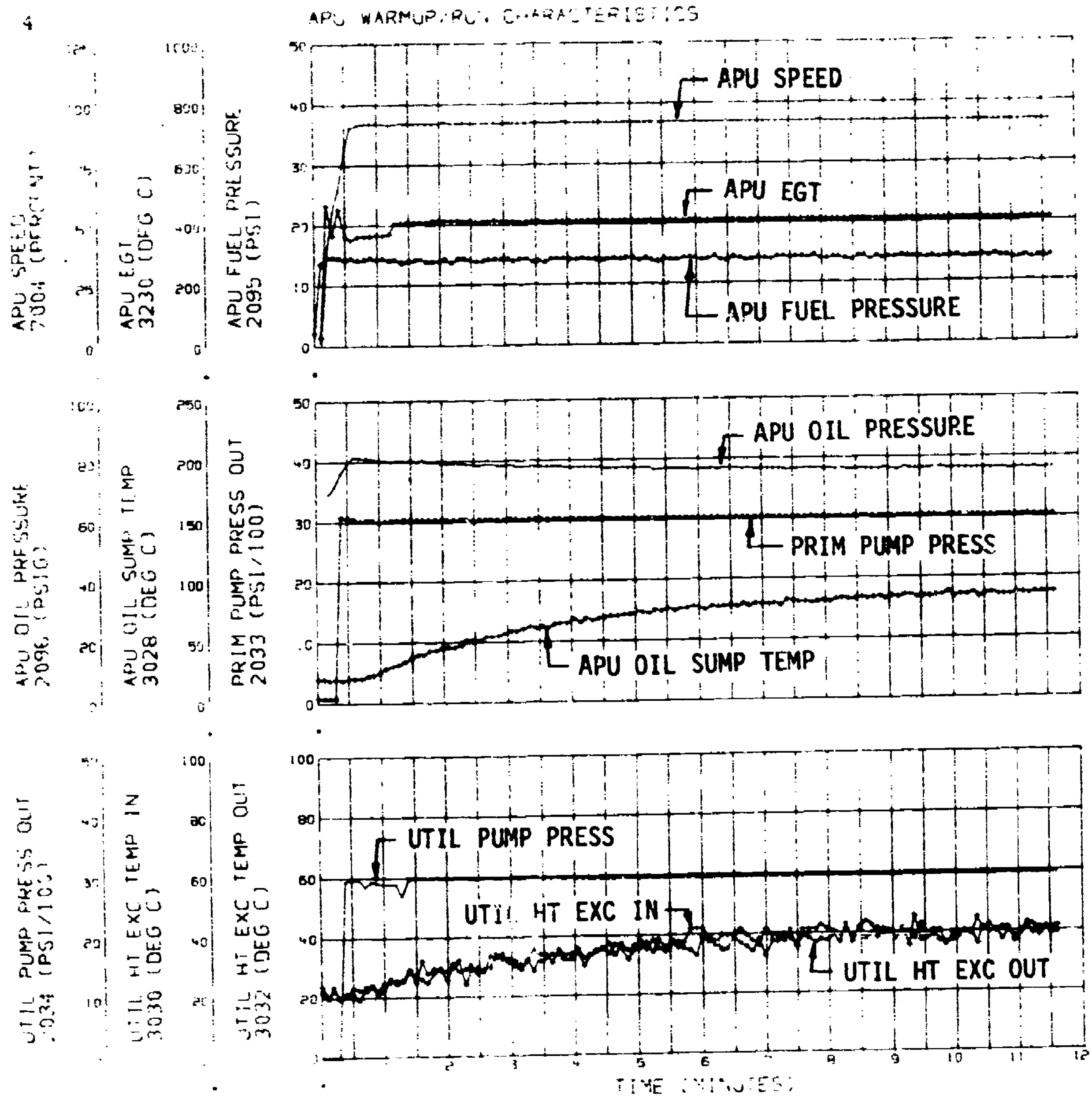


FIGURE 10
APU WARM-UP/RUN CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. APU SERVICED WITH MIL-L-23699C OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID
3. JP-4 FUEL UTILIZED
4. APU SPEED INSTRUMENTATION READS APPROXIMATELY 25% LOW
5. APU OIL SUMP TEMP INSTRUMENTATION FAILED

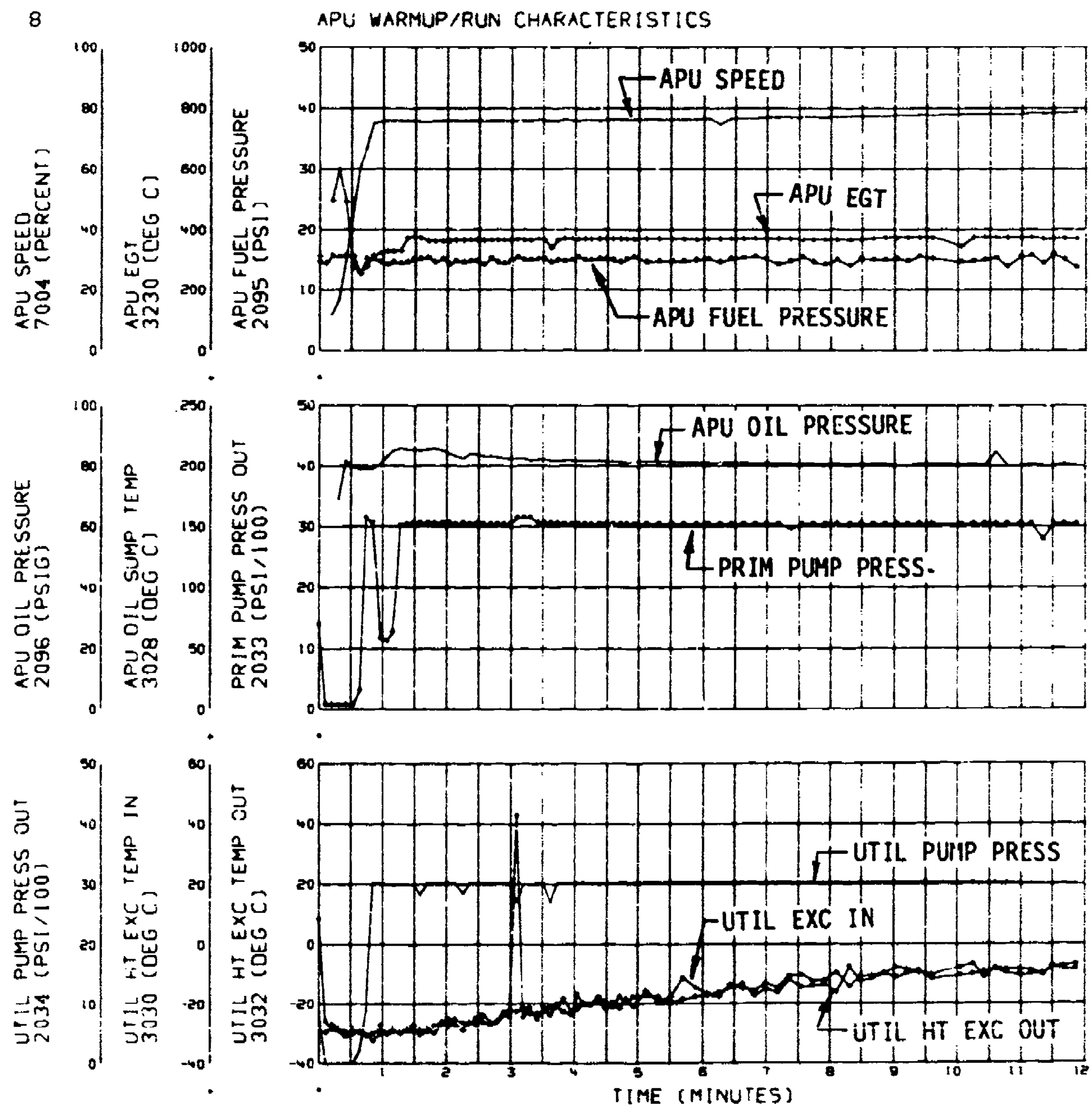


FIGURE 11
APU WARM-UP/RUN CHARACTERISTICS
APU S/N P113
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. ACCESSORY GEARBOX CLUTCH ENGAGED THEN FAILED

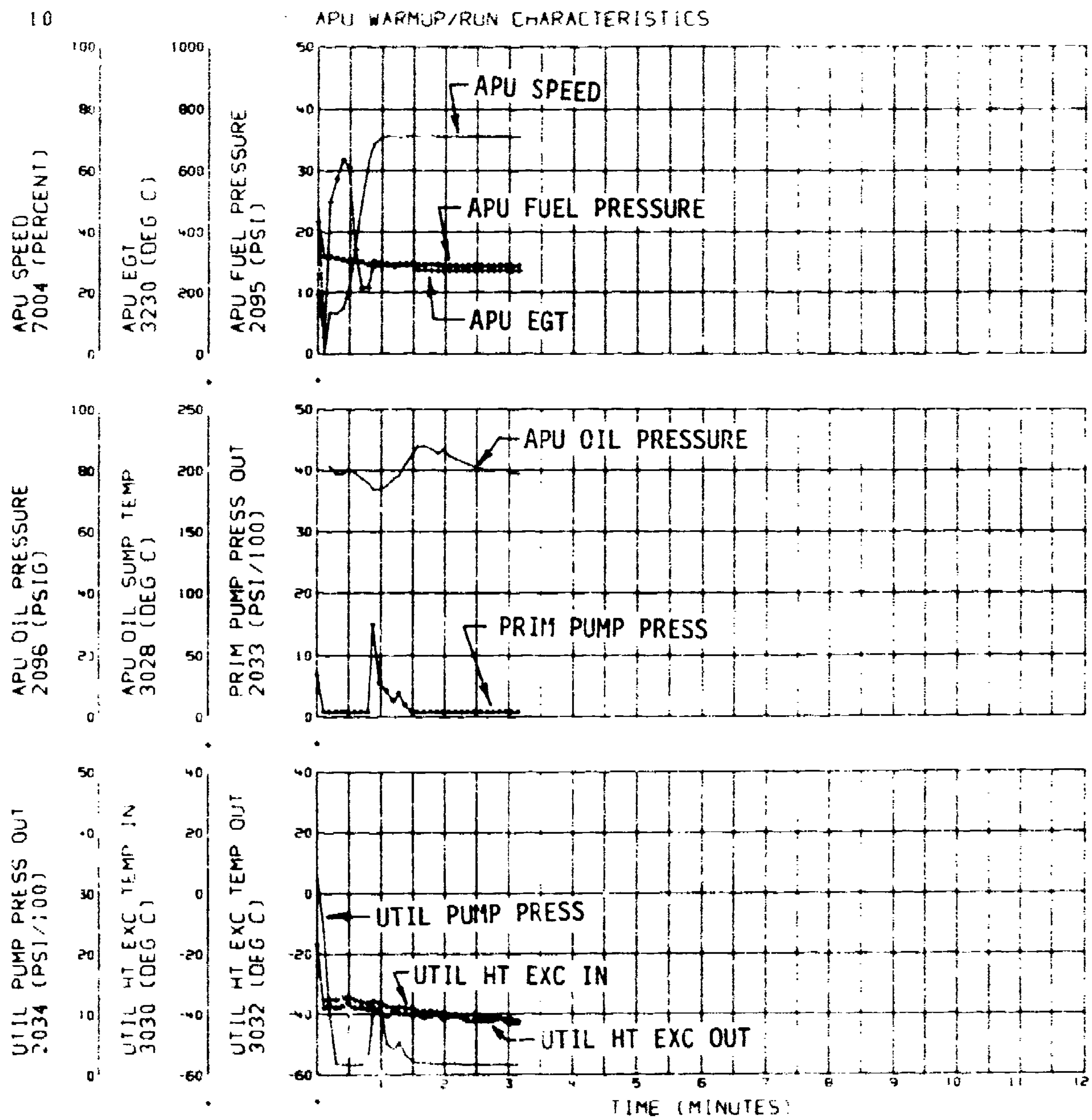


FIGURE 12

APU WARM-UP/RUN CHARACTERISTICS

APU S/N P113

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. APU SERVICED WITH MIL-L-7808H OIL
2. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
3. JP-4 FUEL UTILIZED
4. APU OIL SUMP TEMPERATURE INSTRUMENTATION FAILED

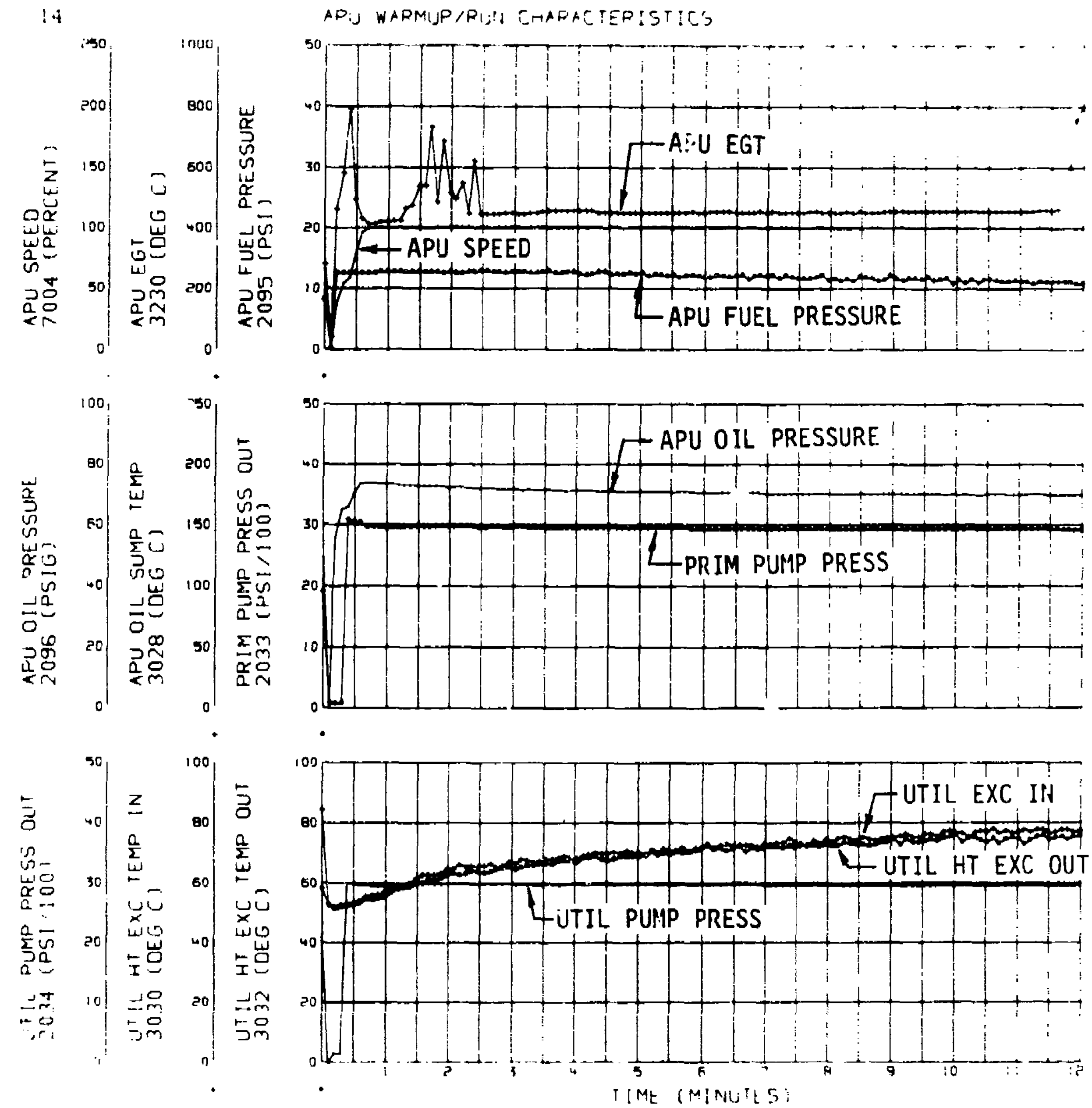


FIGURE 13
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

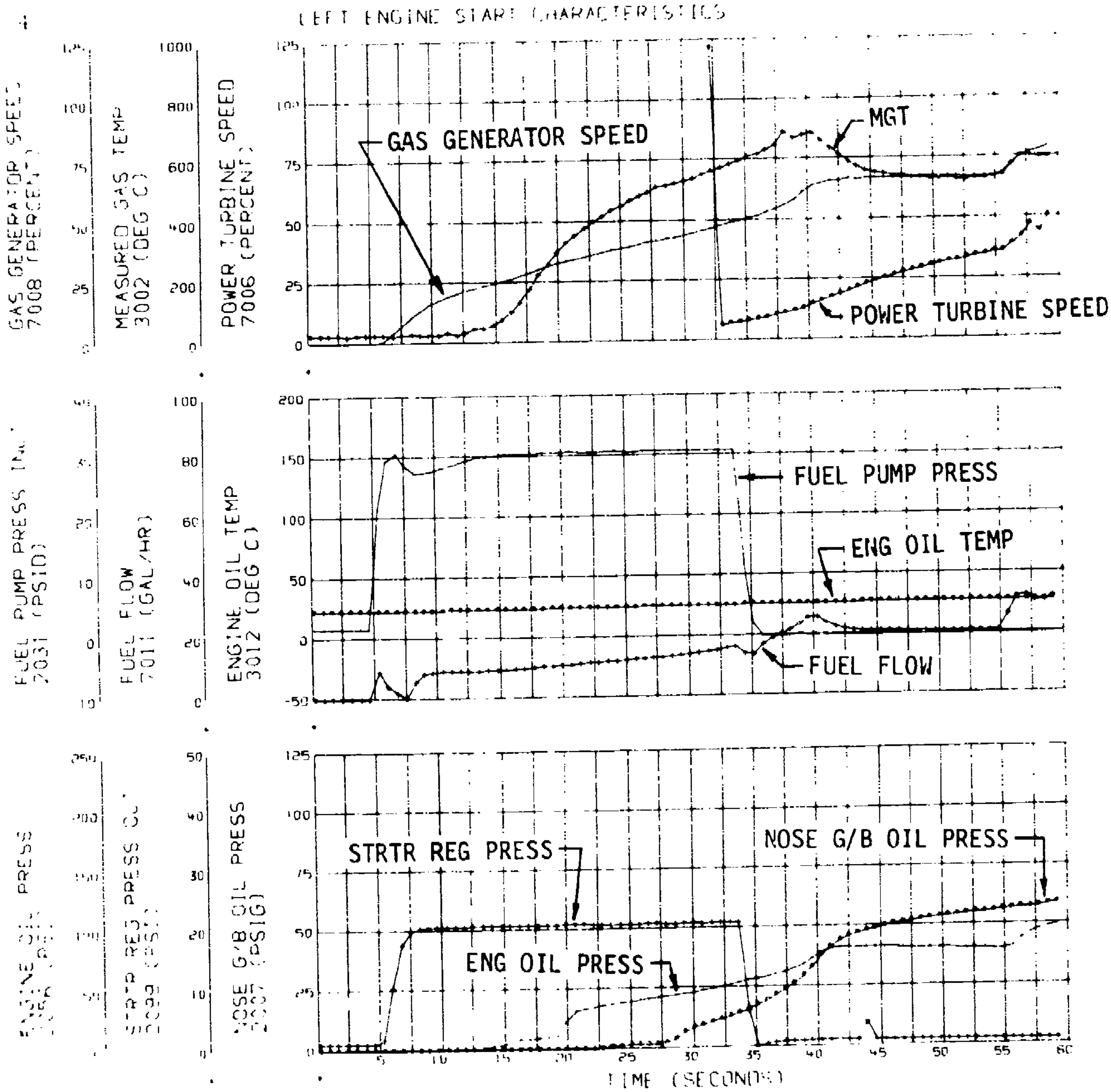


FIGURE 14
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED
3. ENGINE RESTARTED ONE MINUTE AFTER SHUTDOWN

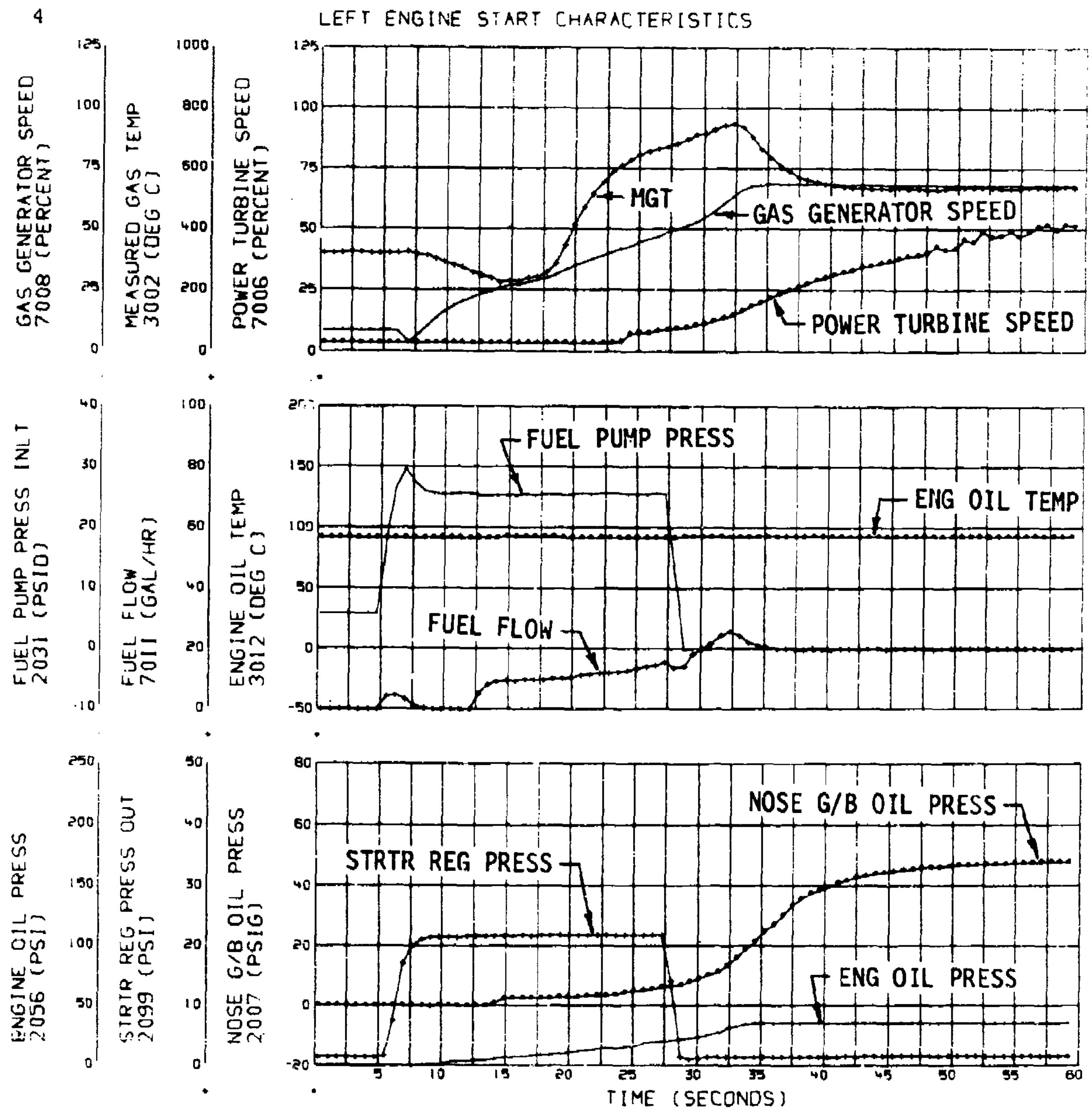


FIGURE 15
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 74-2?249
CLIMATIC LABORATORY TEMPERATUR.. 70°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED
3. ENGINE RE-STARTED TWO MINUTES AFTER SHUTDOWN

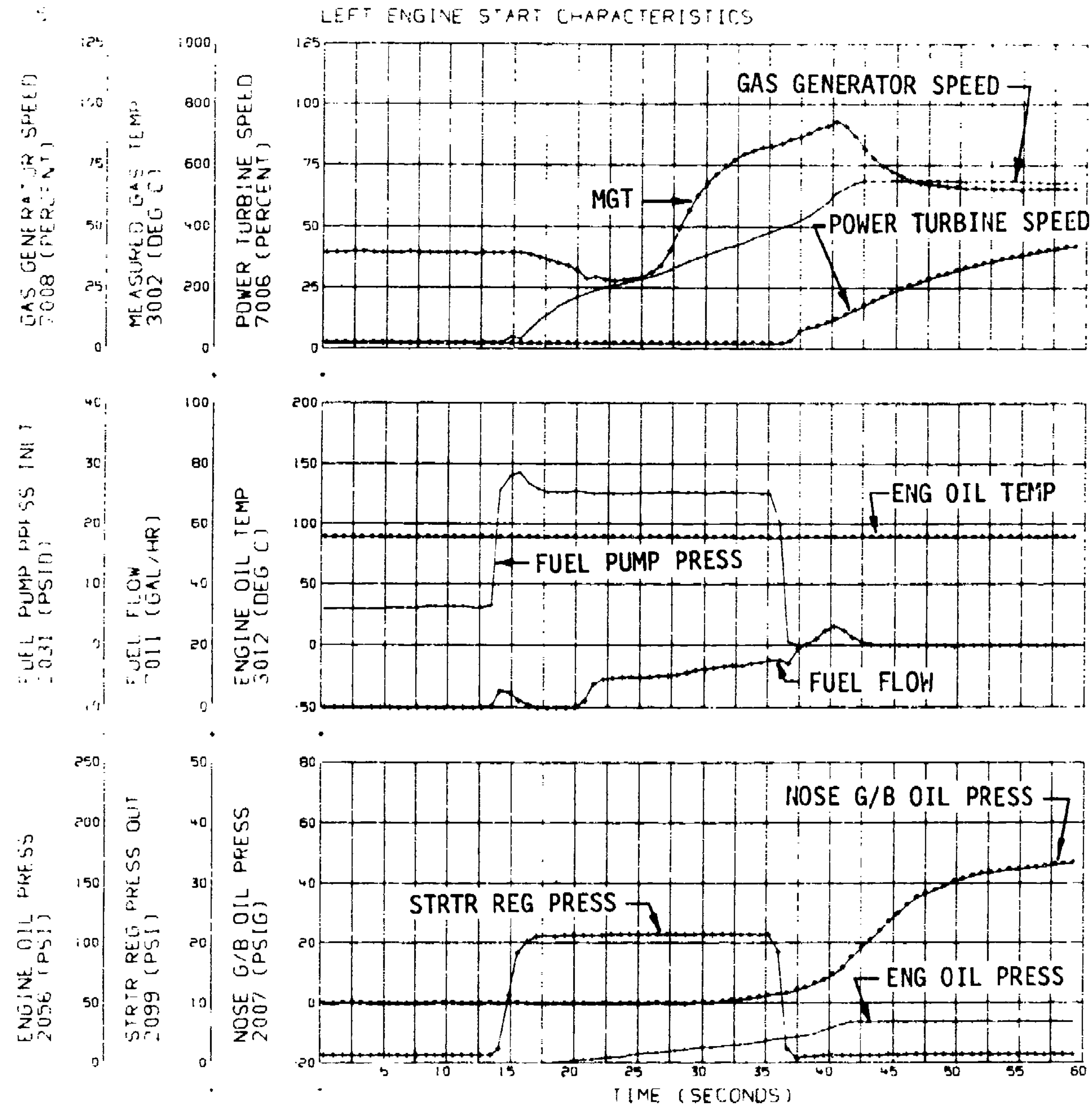


FIGURE 16
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED
3. POWER TURBINE DID NOT START TURNING UNTIL LATER IN THE START SEQUENCE

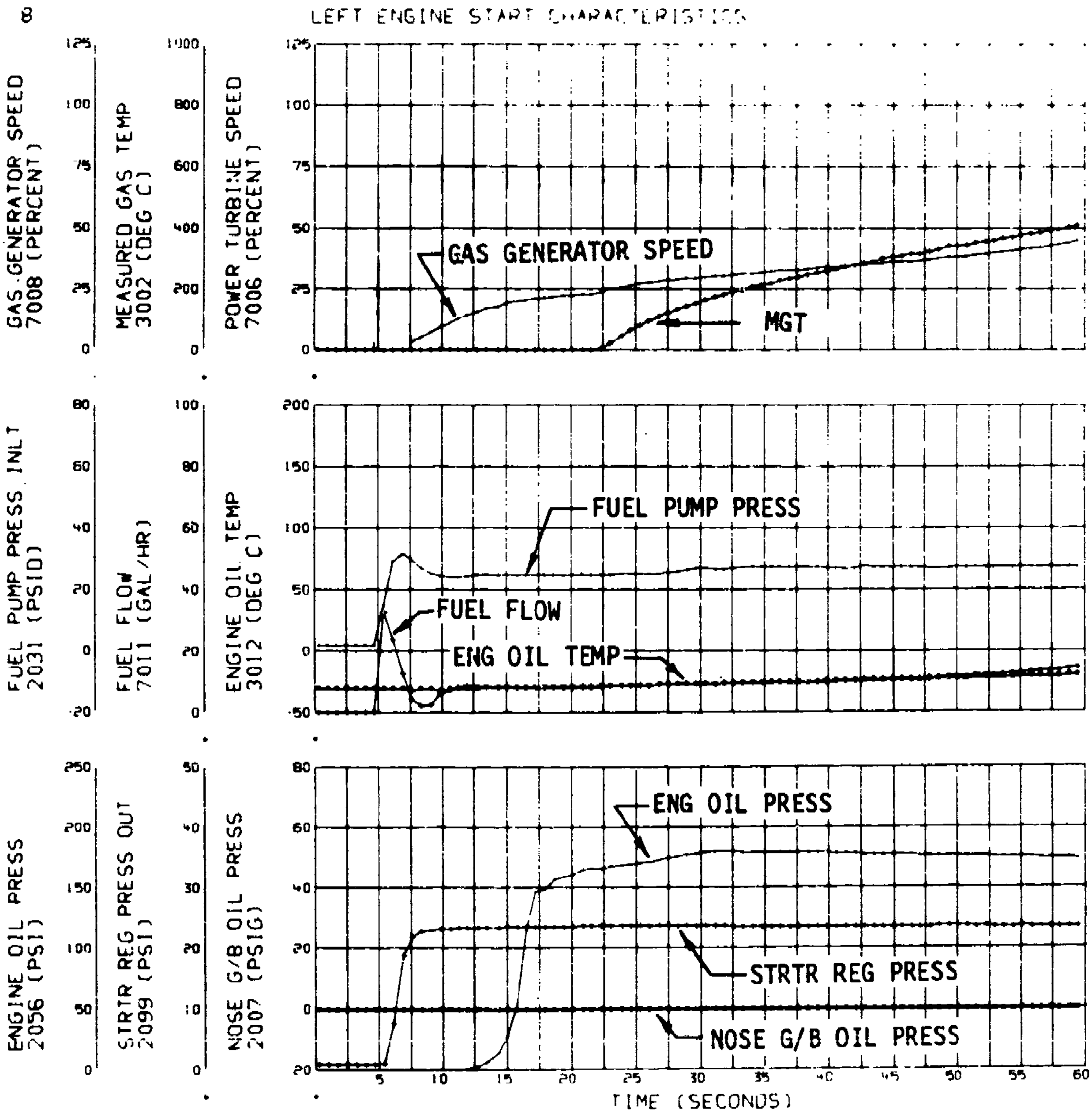


FIGURE 17

NO 1 ENGINE START CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:

1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. ENGINE START ATTEMPT ABORTED AFTER TWO MINUTES
4. PNEUMATIC POWER CART USED FOR START ATTEMPT

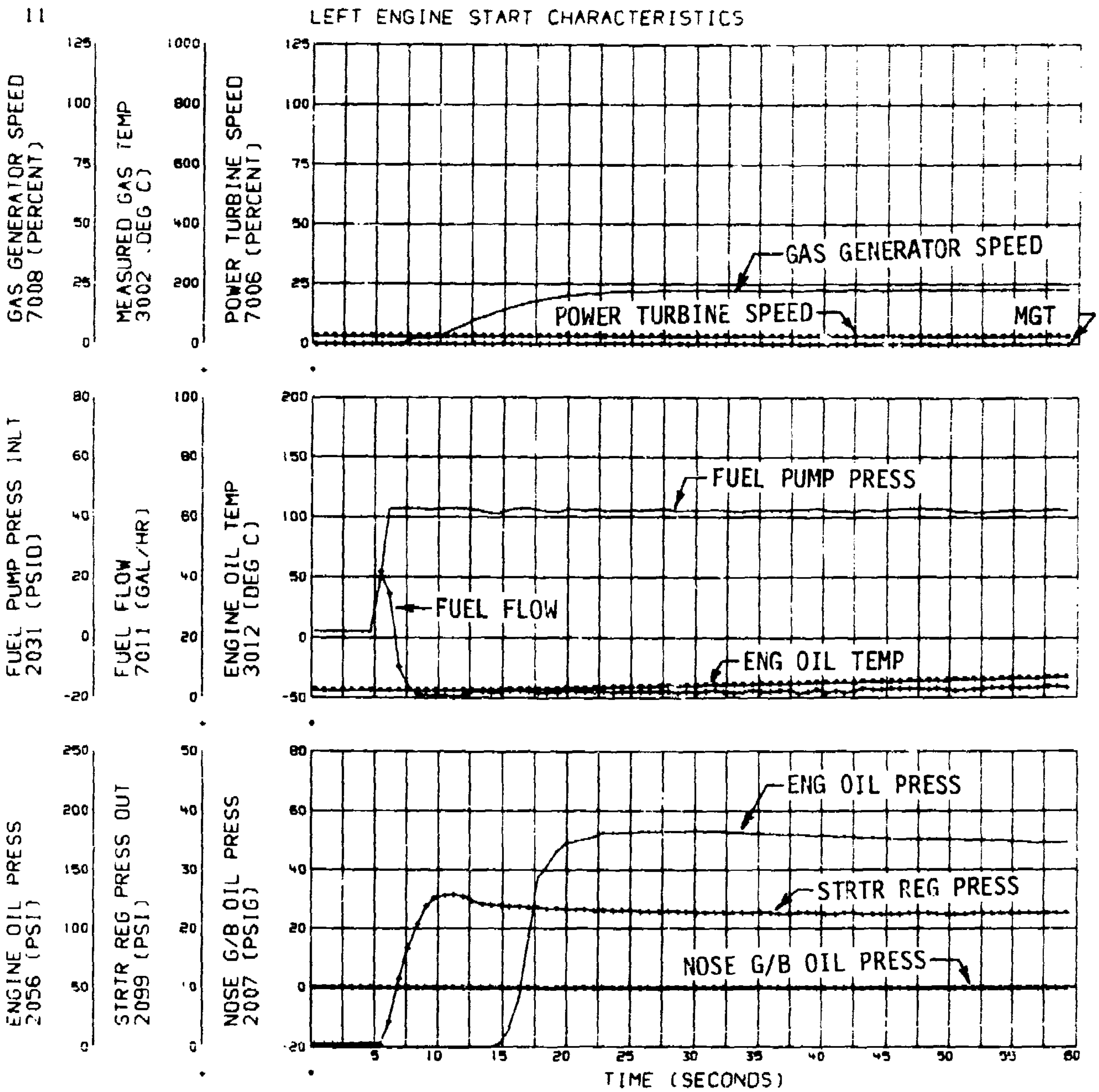


FIGURE 18

NO 1 ENGINE START CHARACTERISTICS
T-700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-6708H OIL
2. JP-4 FUEL UTILIZED
3. PRESSURIZED AIR FOR START PROVIDED BY PNEUMATIC POWER CART
4. POWER TURBINE DID NOT START TURNING UNTIL LATER IN SEQUENCE

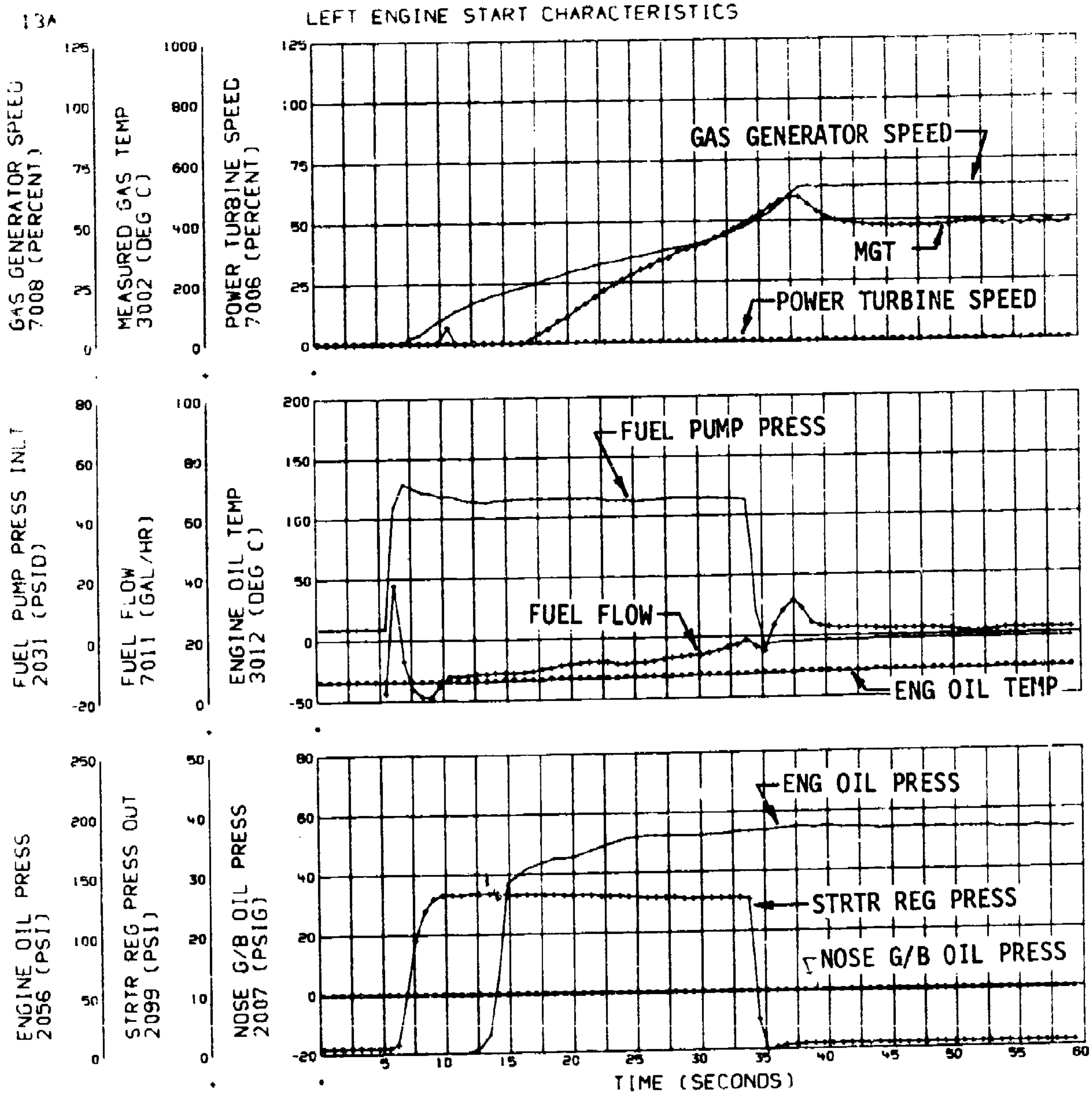


FIGURE 19

NO 1 ENGINE START CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED

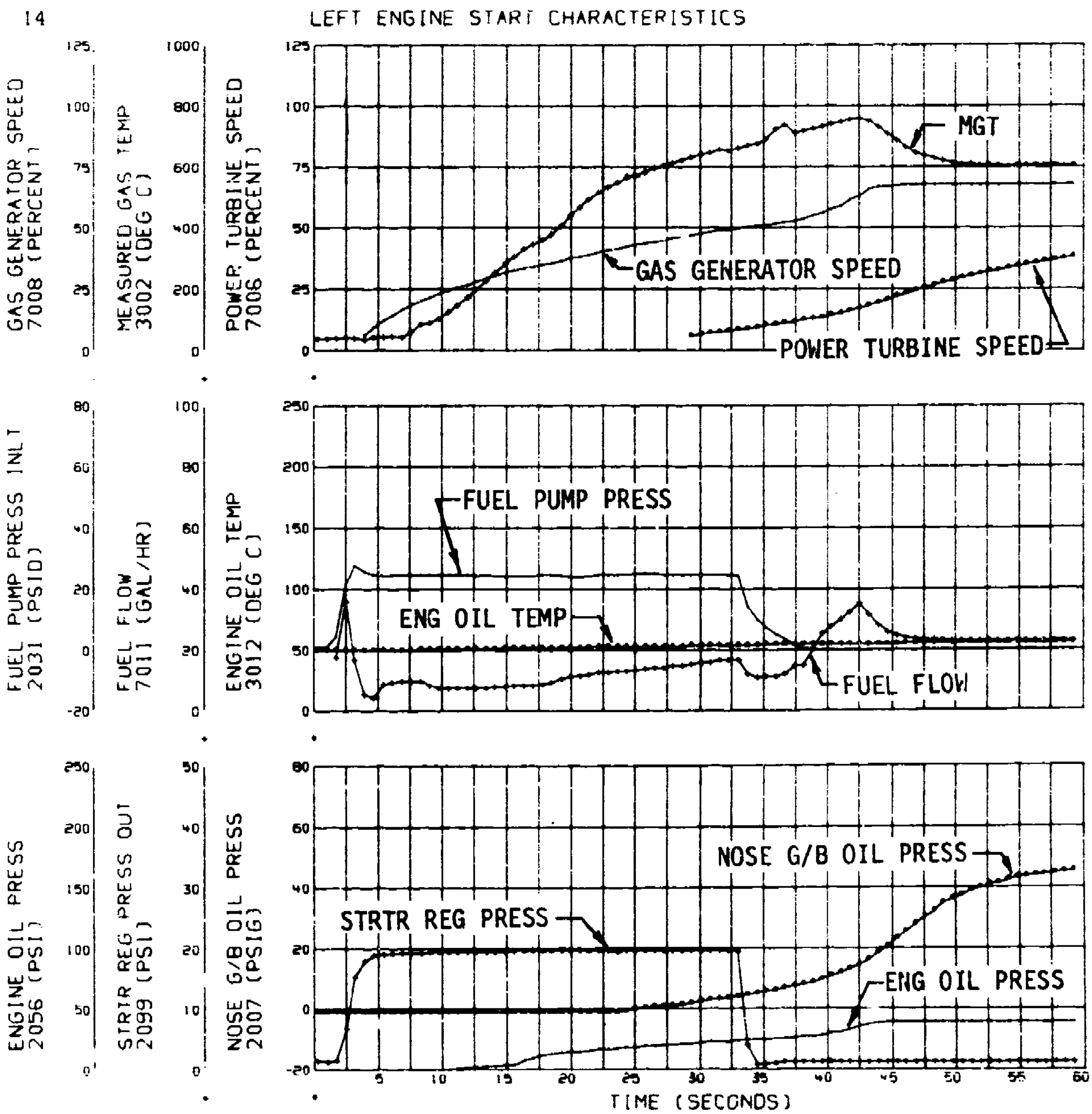


FIGURE 20
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700 ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. ENGINE RE-STARTED ONE MINUTE AFTER SHUTDOWN
4. FUEL FLOW INSTRUMENTATION FAILED

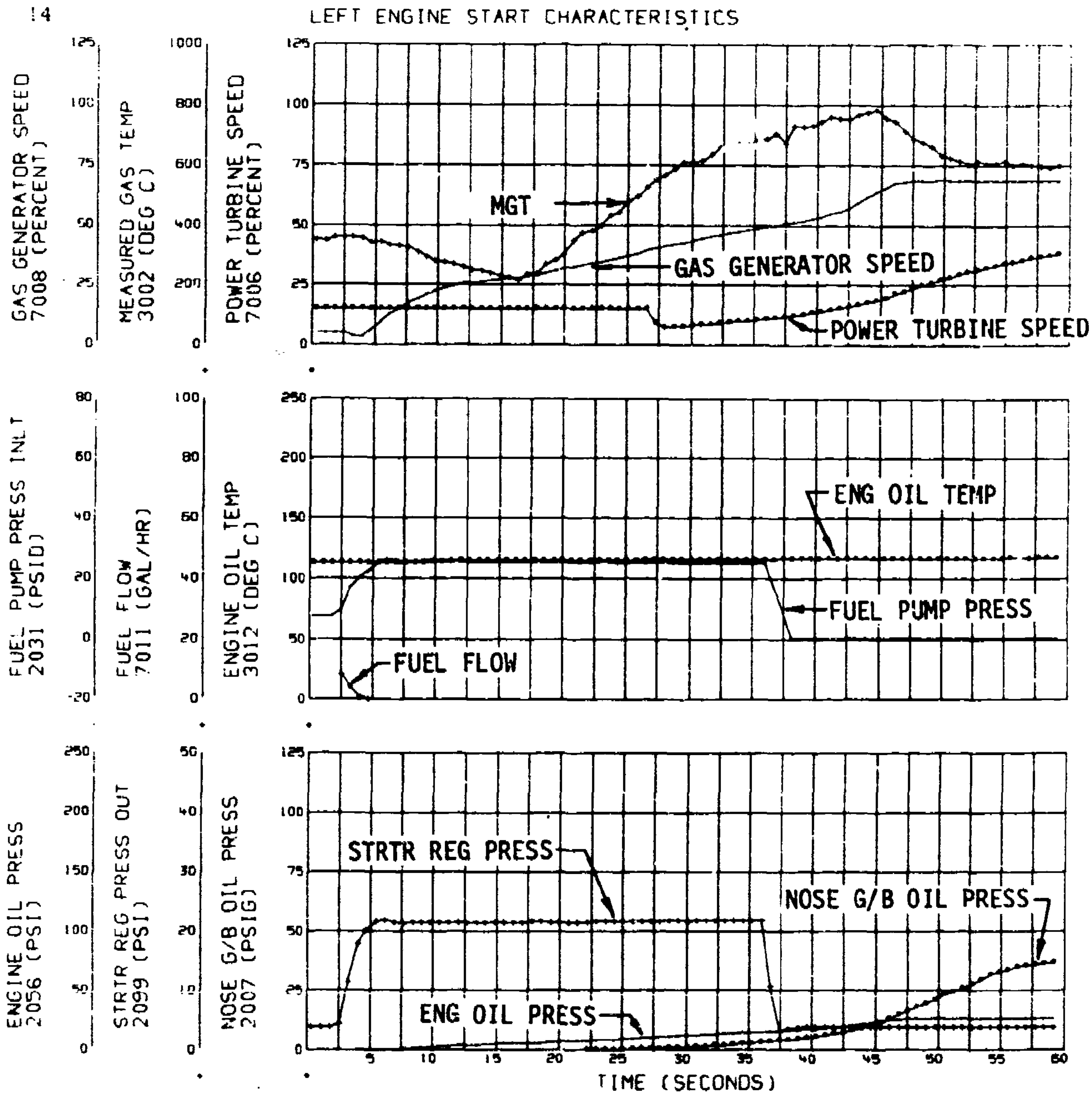


FIGURE 21
NO 1 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. FUEL FLOW INSTRUMENTATION FAILED
4. ENGINE RESTARTED TWO MINUTES AFTER SHUTDOWN

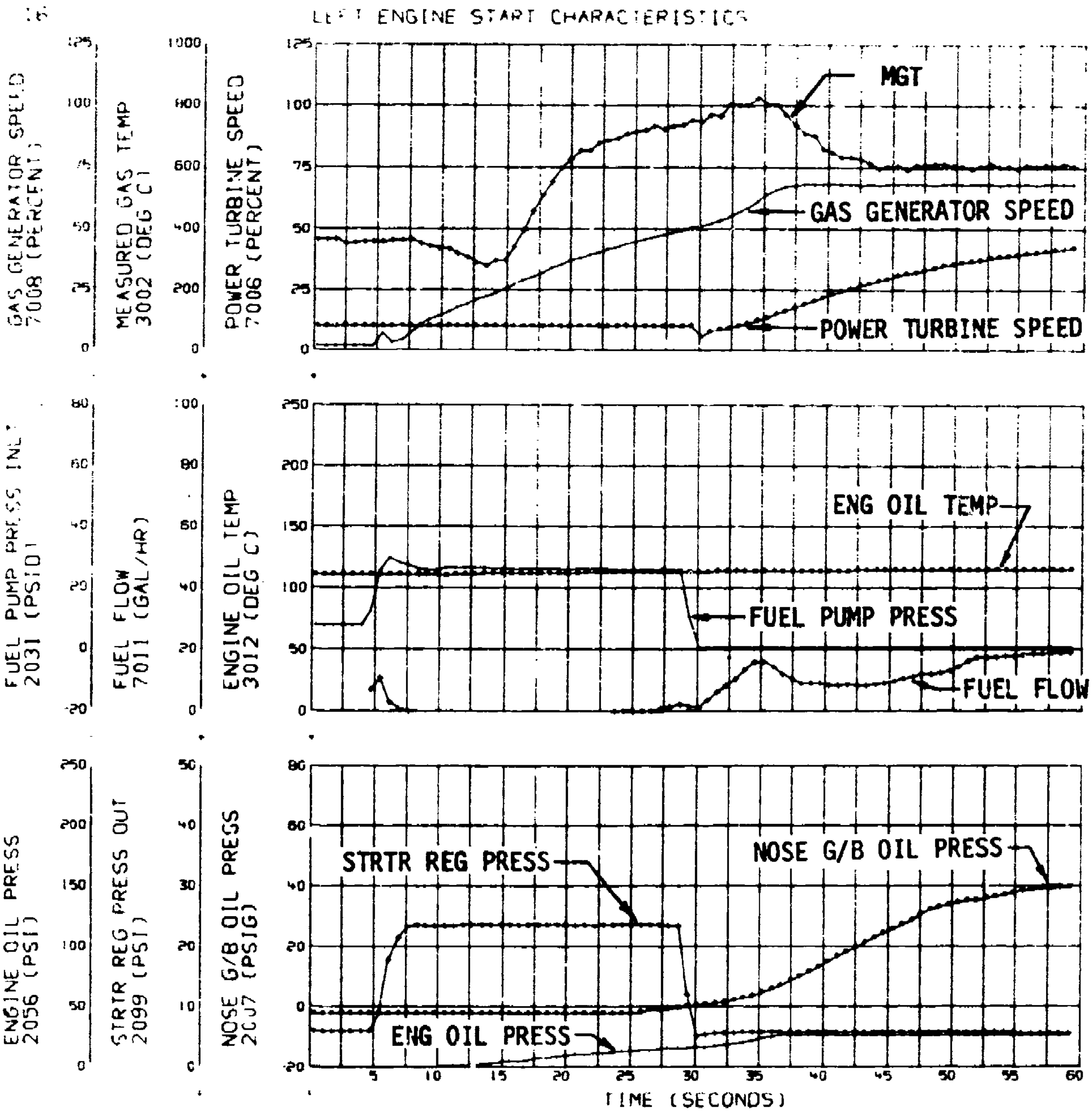


FIGURE 22
NO 2 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-241R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

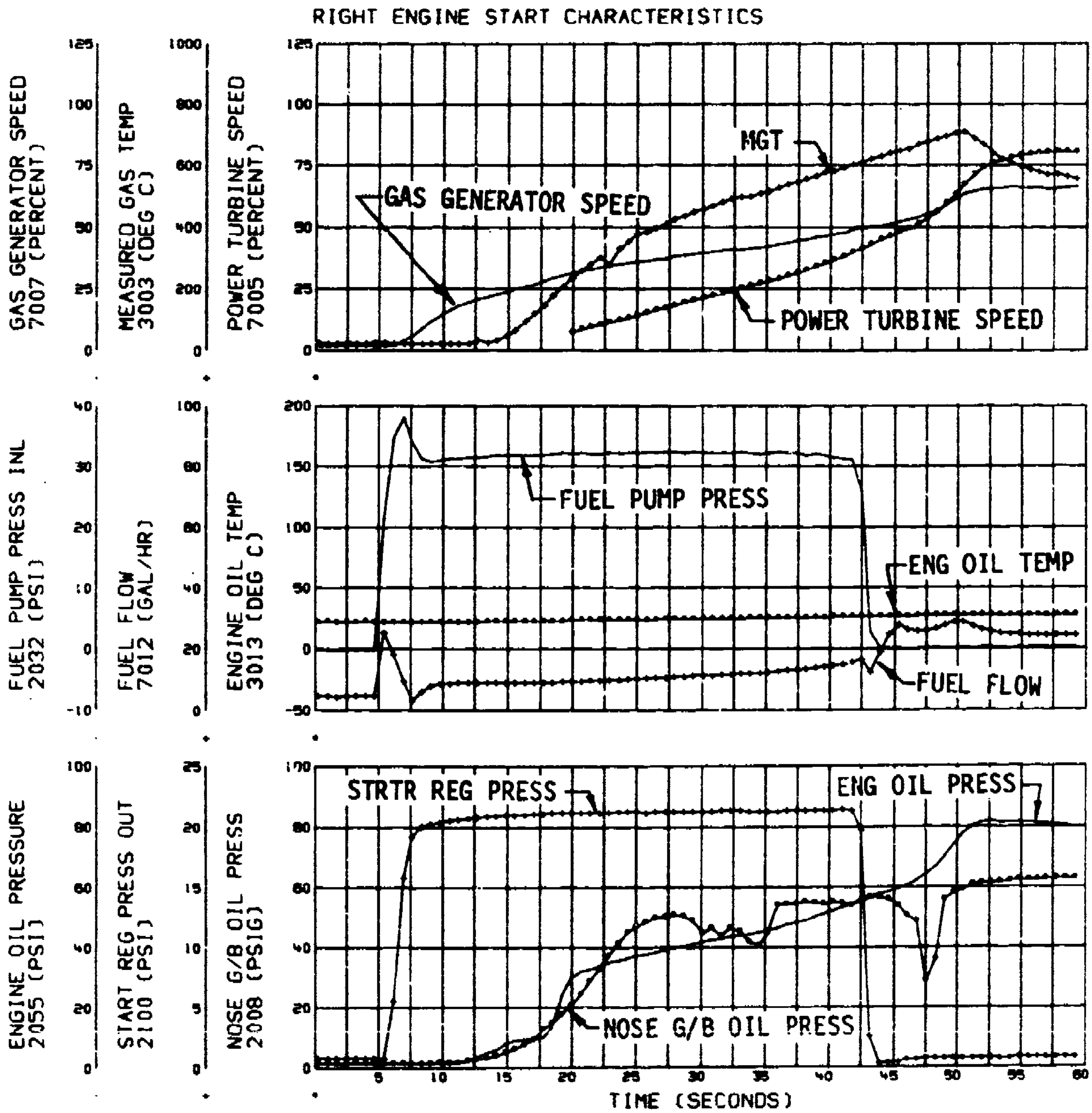


FIGURE 23
NO 2 ENGINE START CHARACTERISTICS
T-700-GE-700R ENGINE S/N 207-241R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED
3. STARTER REGULATOR AIR PRESSURE READS APPROXIMATELY 25 PSI HIGH.

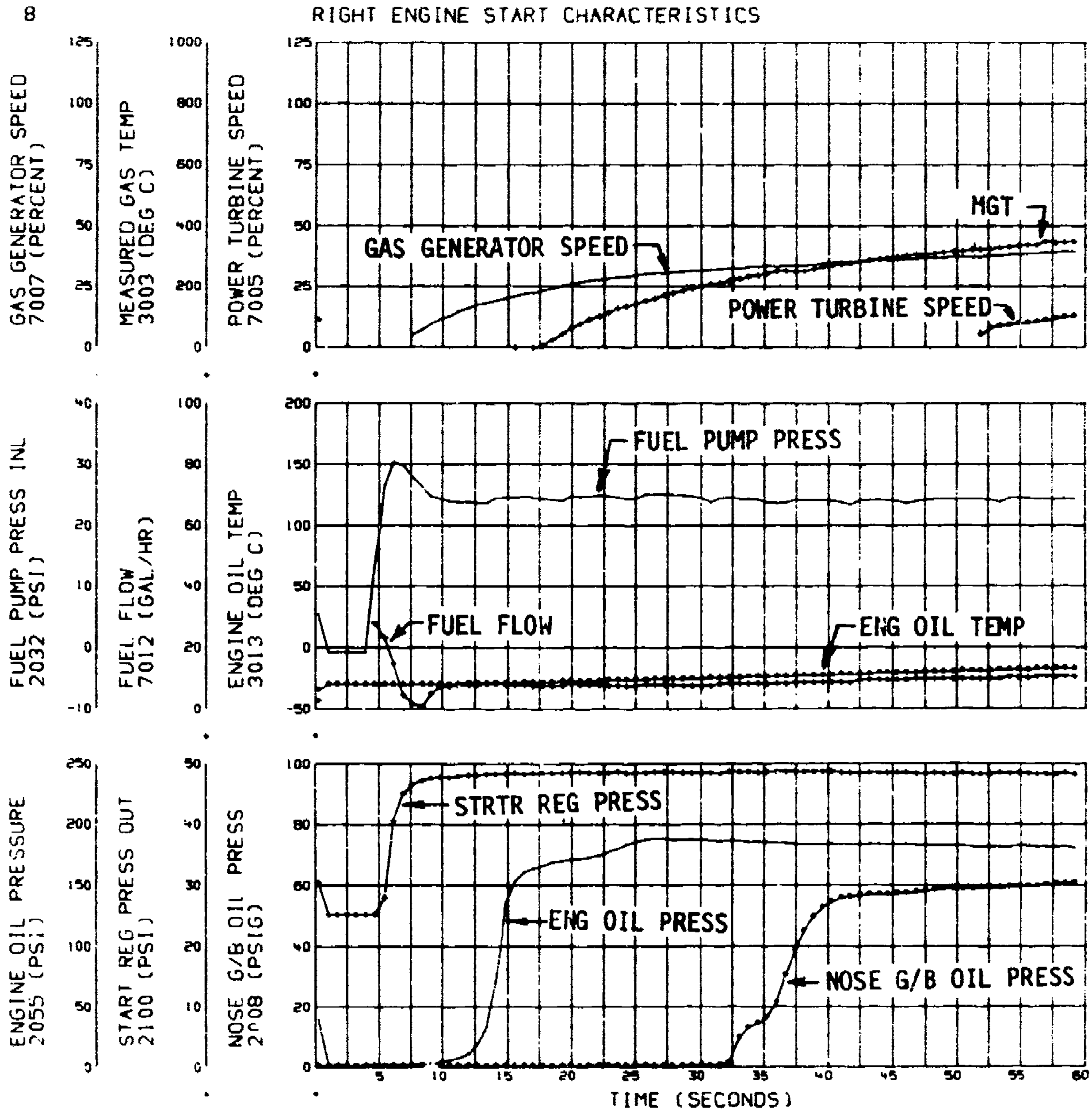


FIGURE 24
NO 2 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-241R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°C

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. STARTER REGULATOR OUTPUT AIR PRESSURE INSTRUMENTATION READS APPRCXIMATELY 25 PSI HIGH

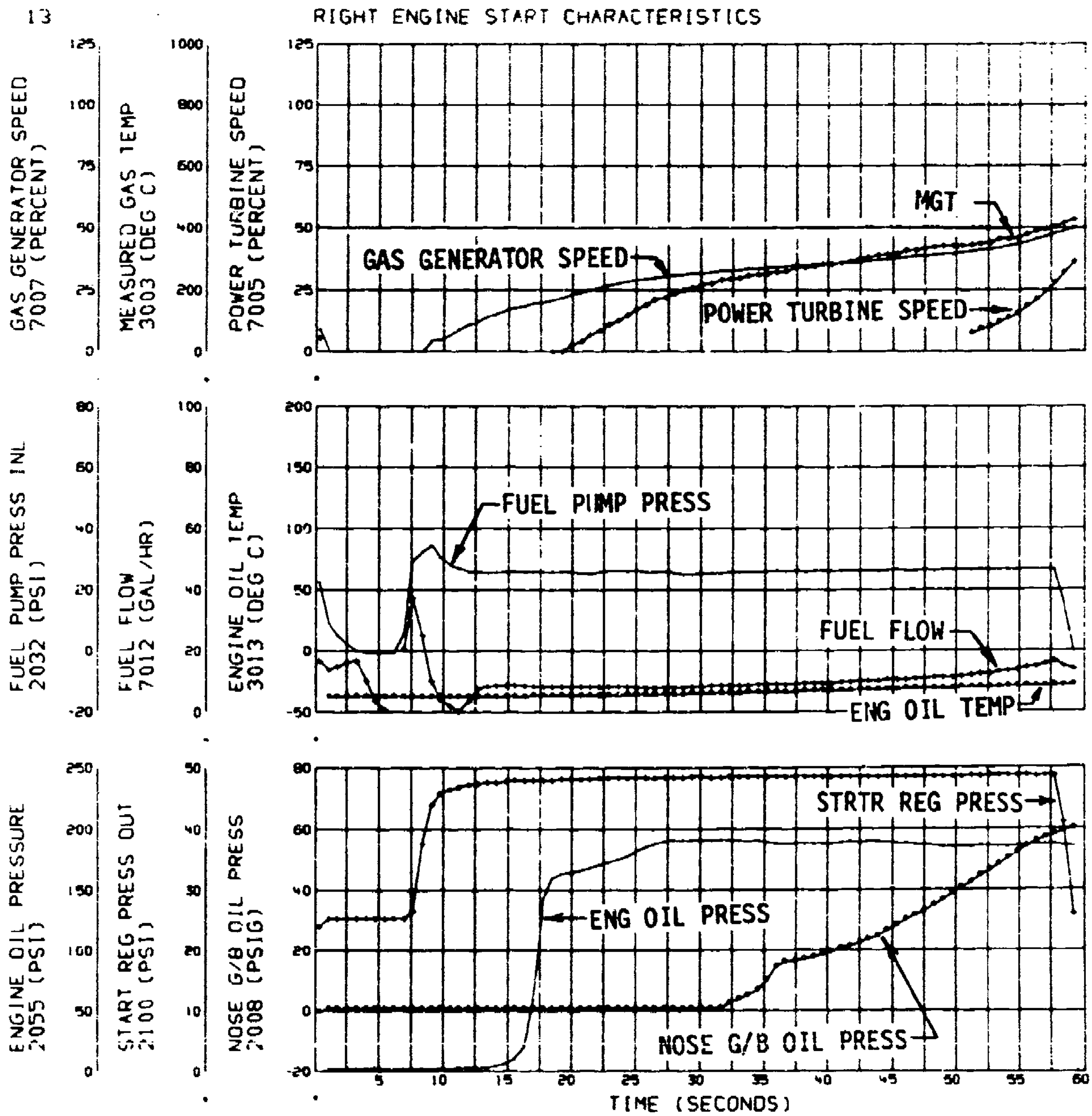


FIGURE 25
NO 2 ENGINE START CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-241R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. STARTER REGULATOR OUTPUT AIR PRESSURE INSTRUMENTATION READS APPROXIMATELY 28 PSI HIGH

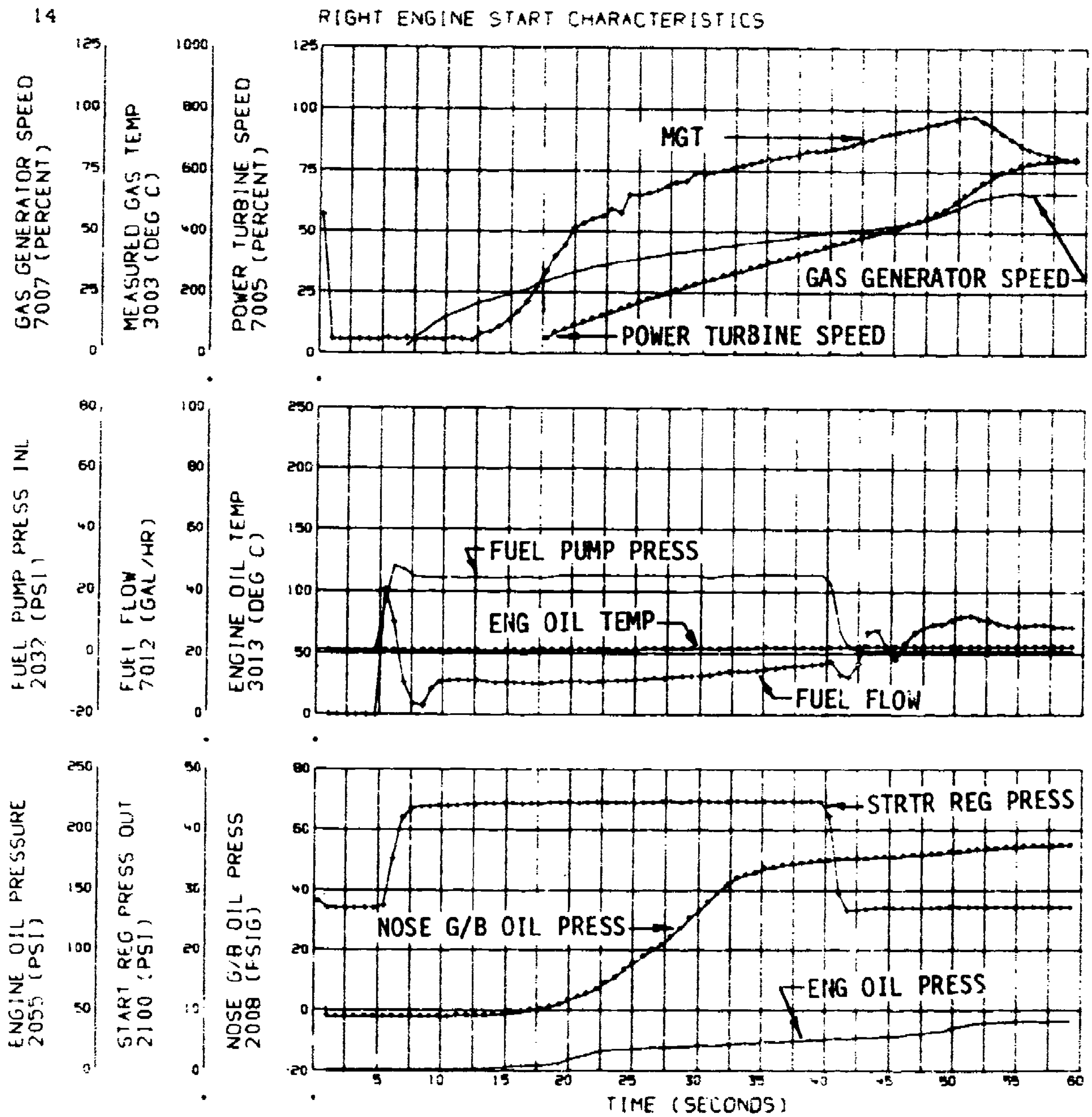


FIGURE 26

NO 1 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

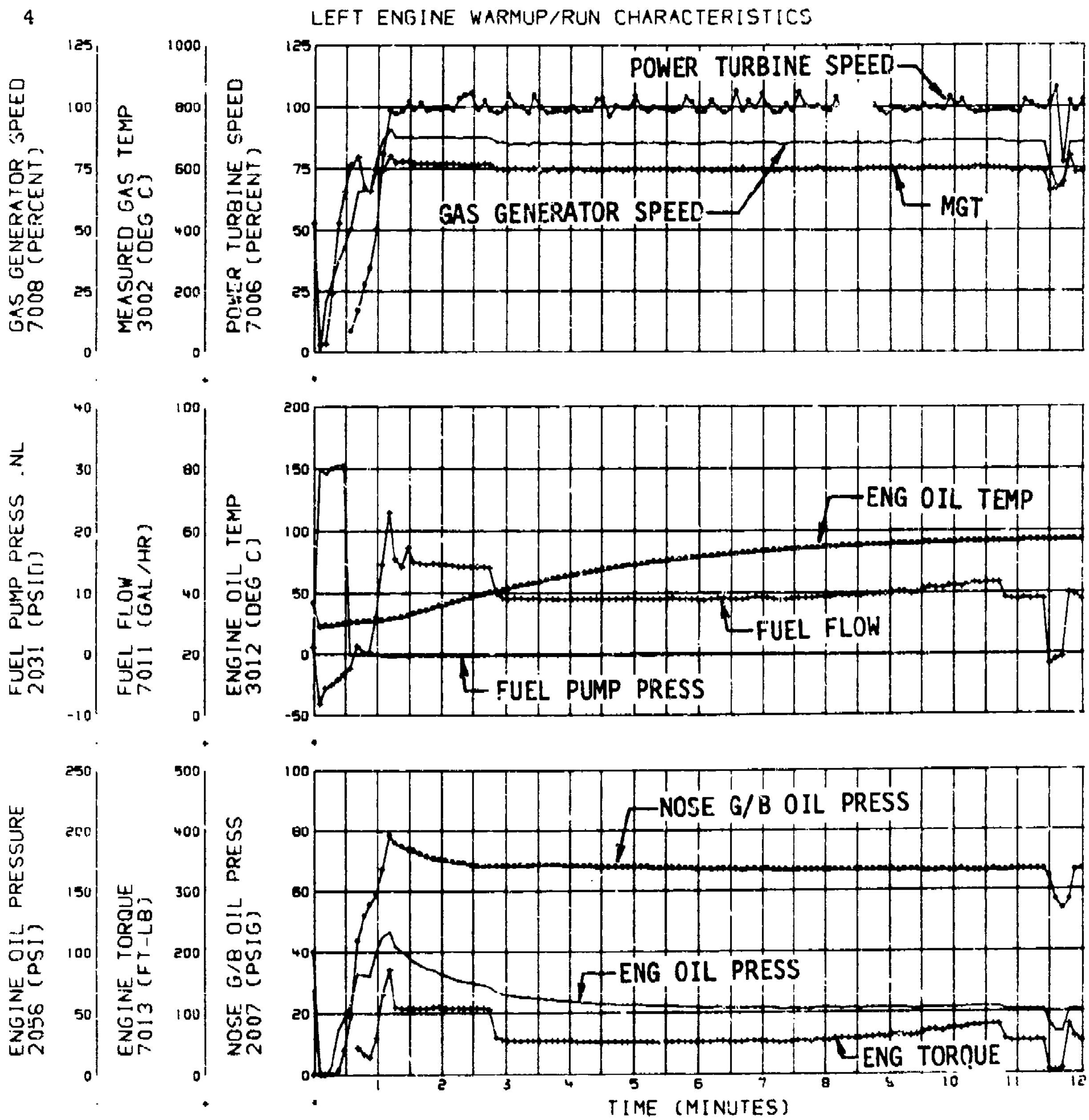


FIGURE 27

NO 1 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

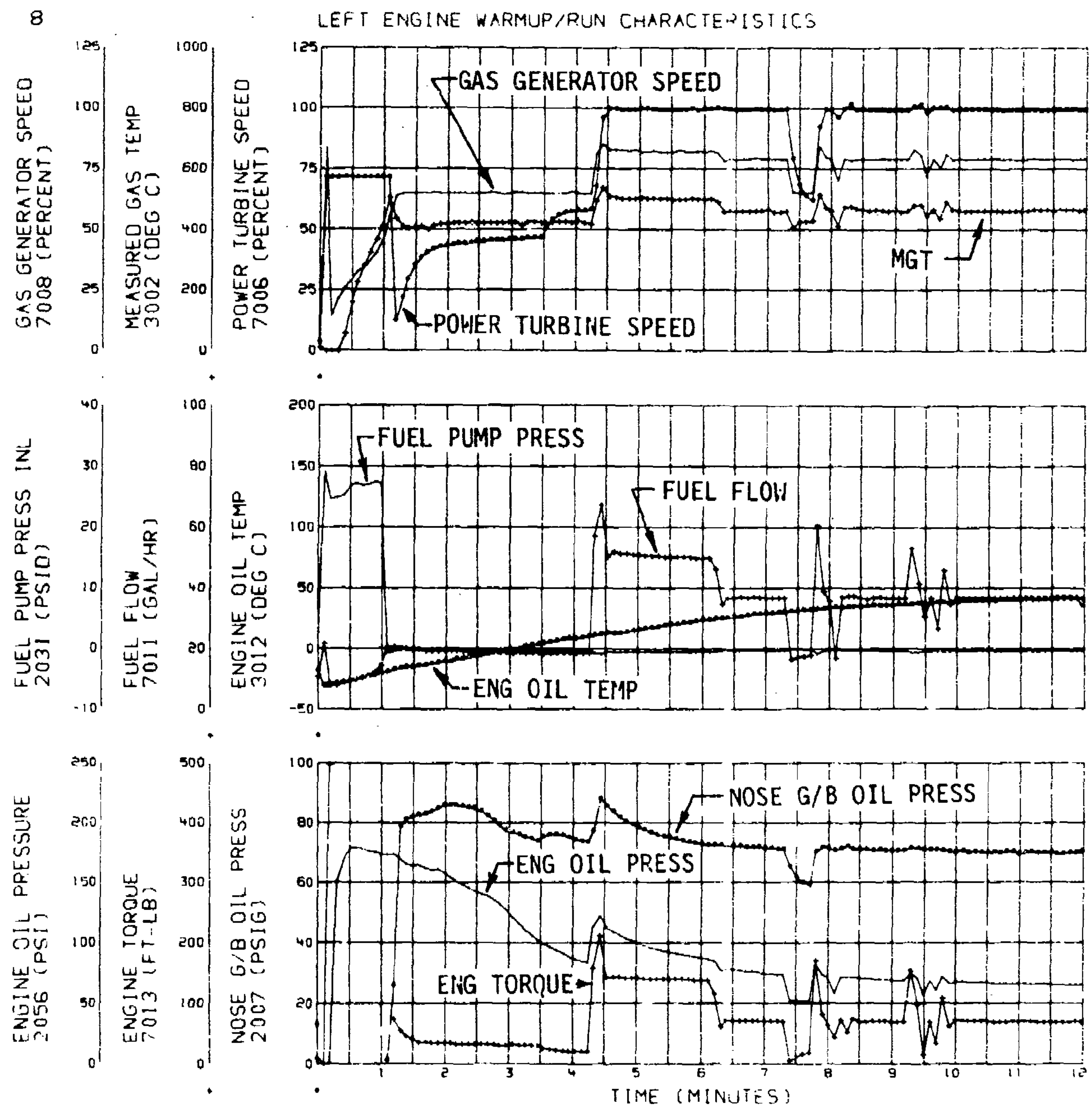


FIGURE 28

NO 1 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808H OIL

2. JP-4 FUEL UTILIZED

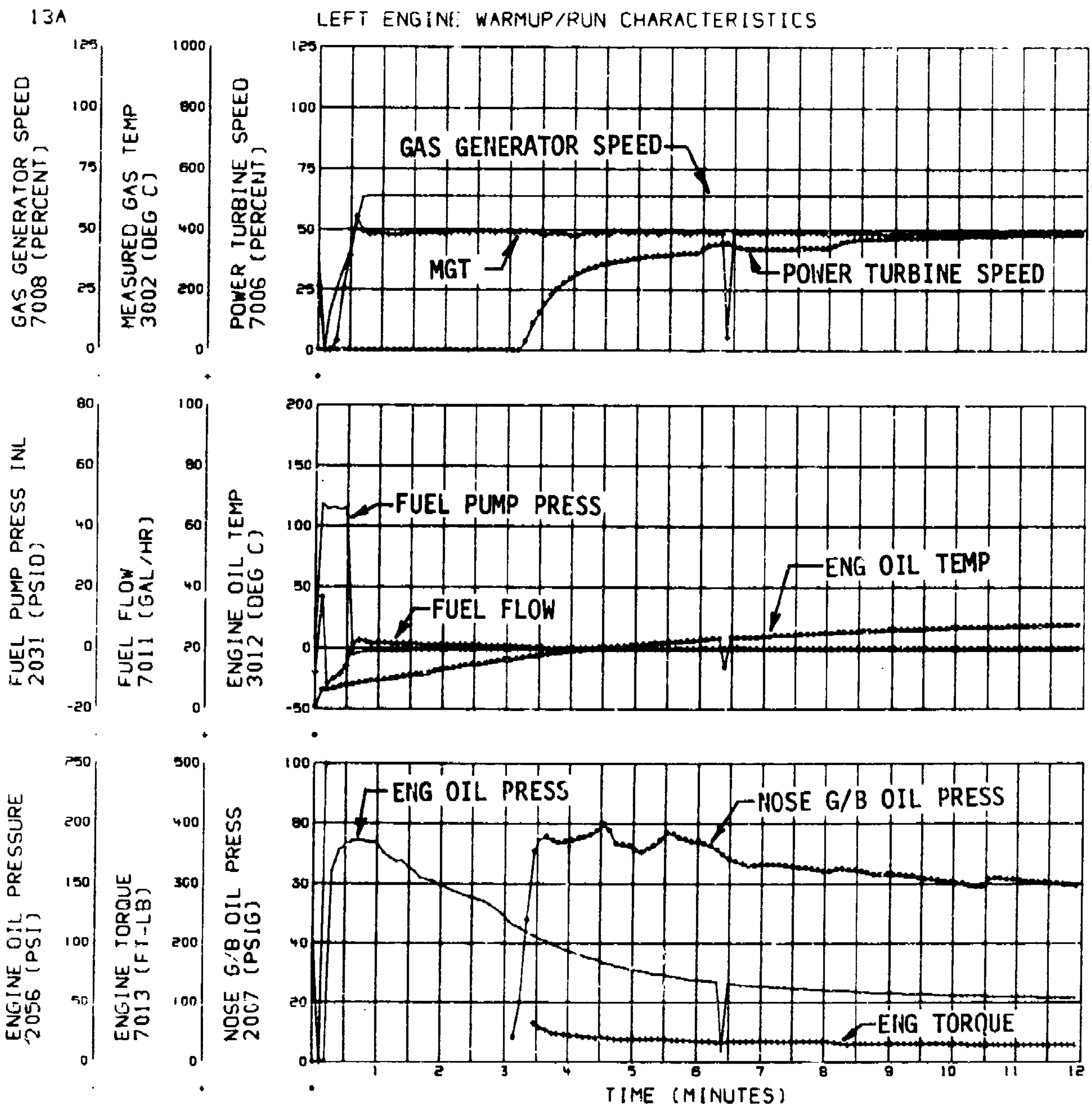


FIGURE 29

NO 1 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED

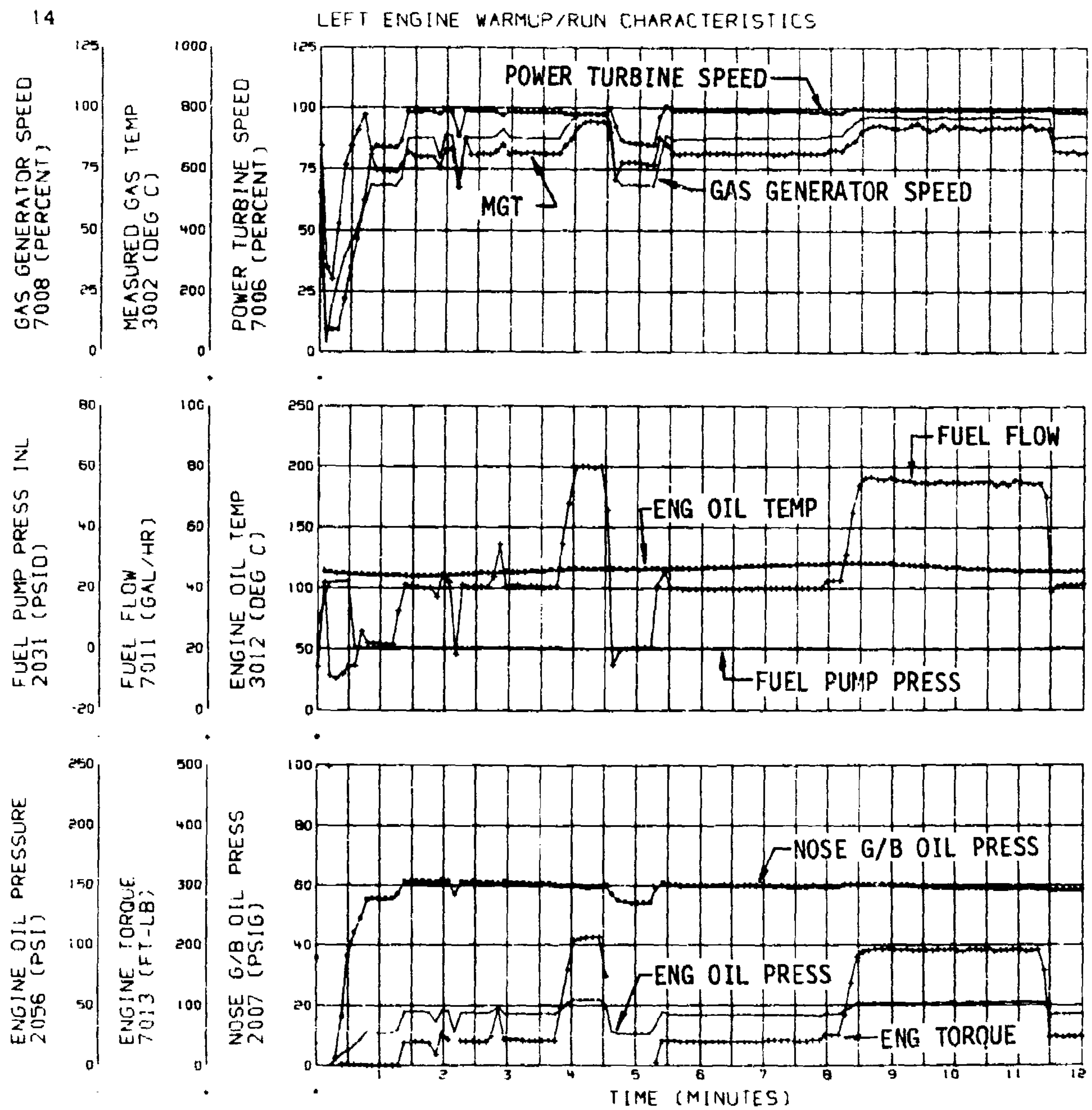


FIGURE 30
NO 2 ENGINE WARM-UP/RUN CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-241R
YAH-64 S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

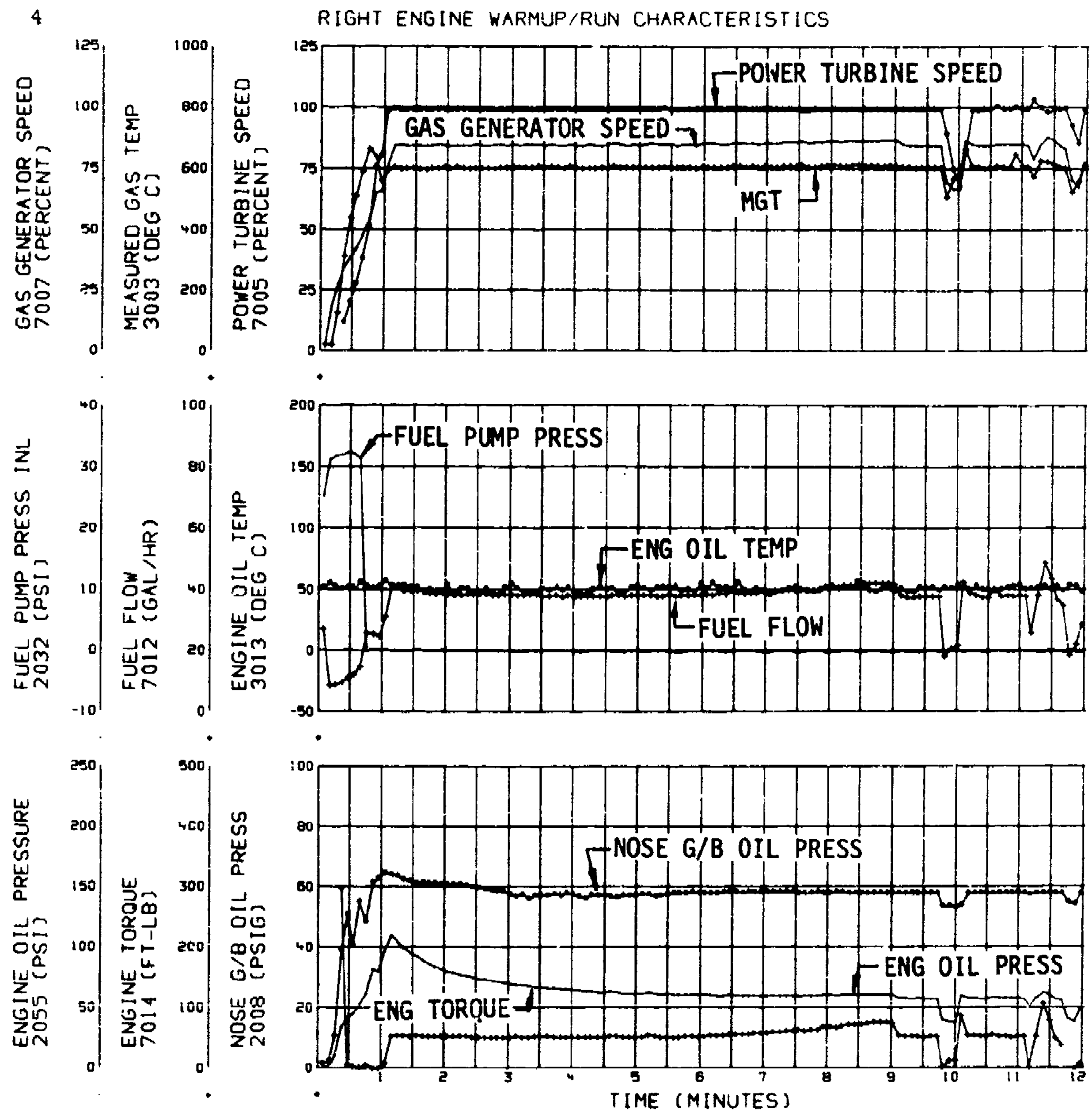


FIGURE 31

NO 2 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-241R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-23699C OIL

2. JP-5 FUEL UTILIZED

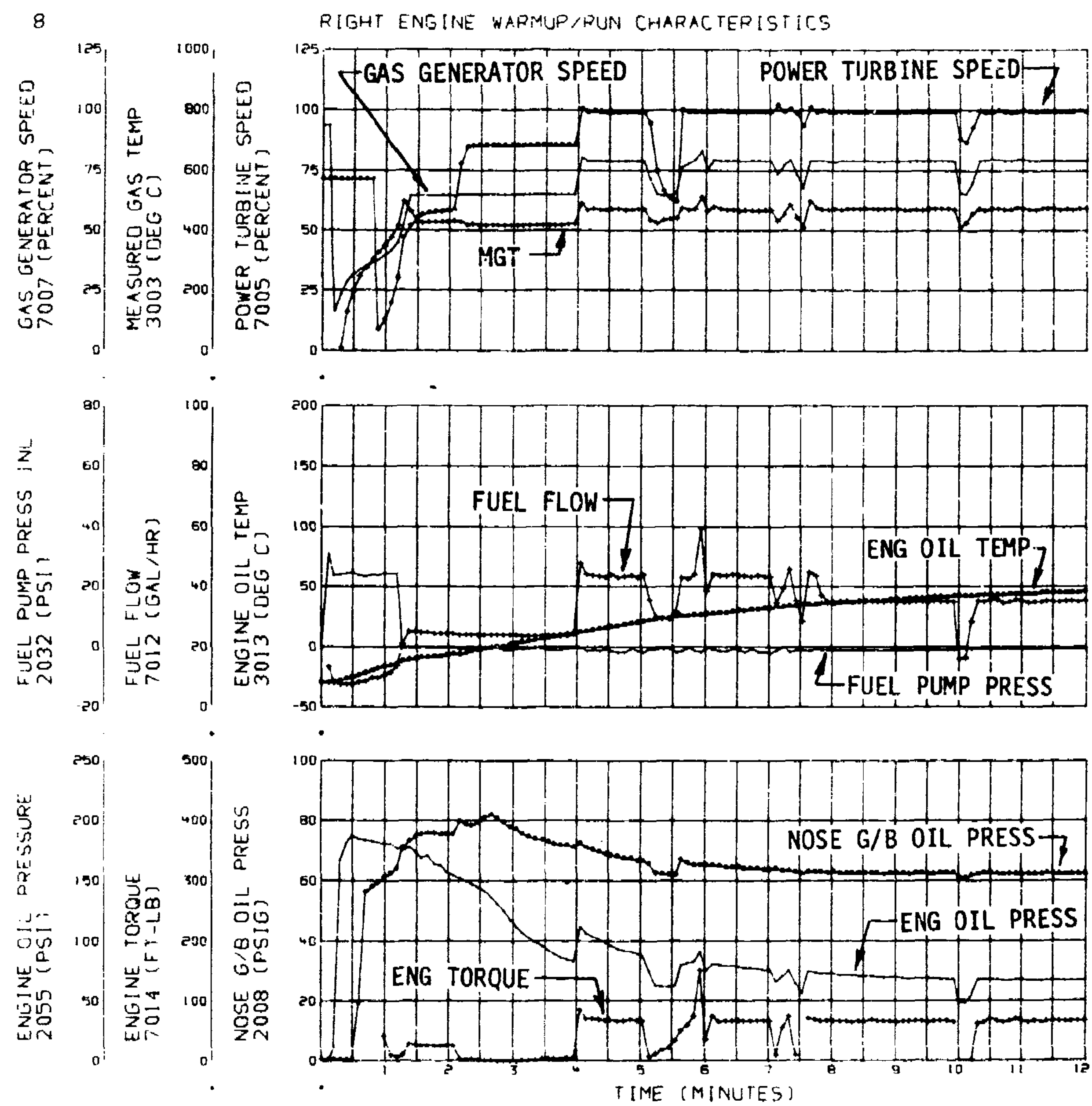


FIGURE 32

NO 2 ENGINE WARM-UP/RUN CHARACTERISTICS

T700-GE-700R ENGINE S/N 207-241R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED

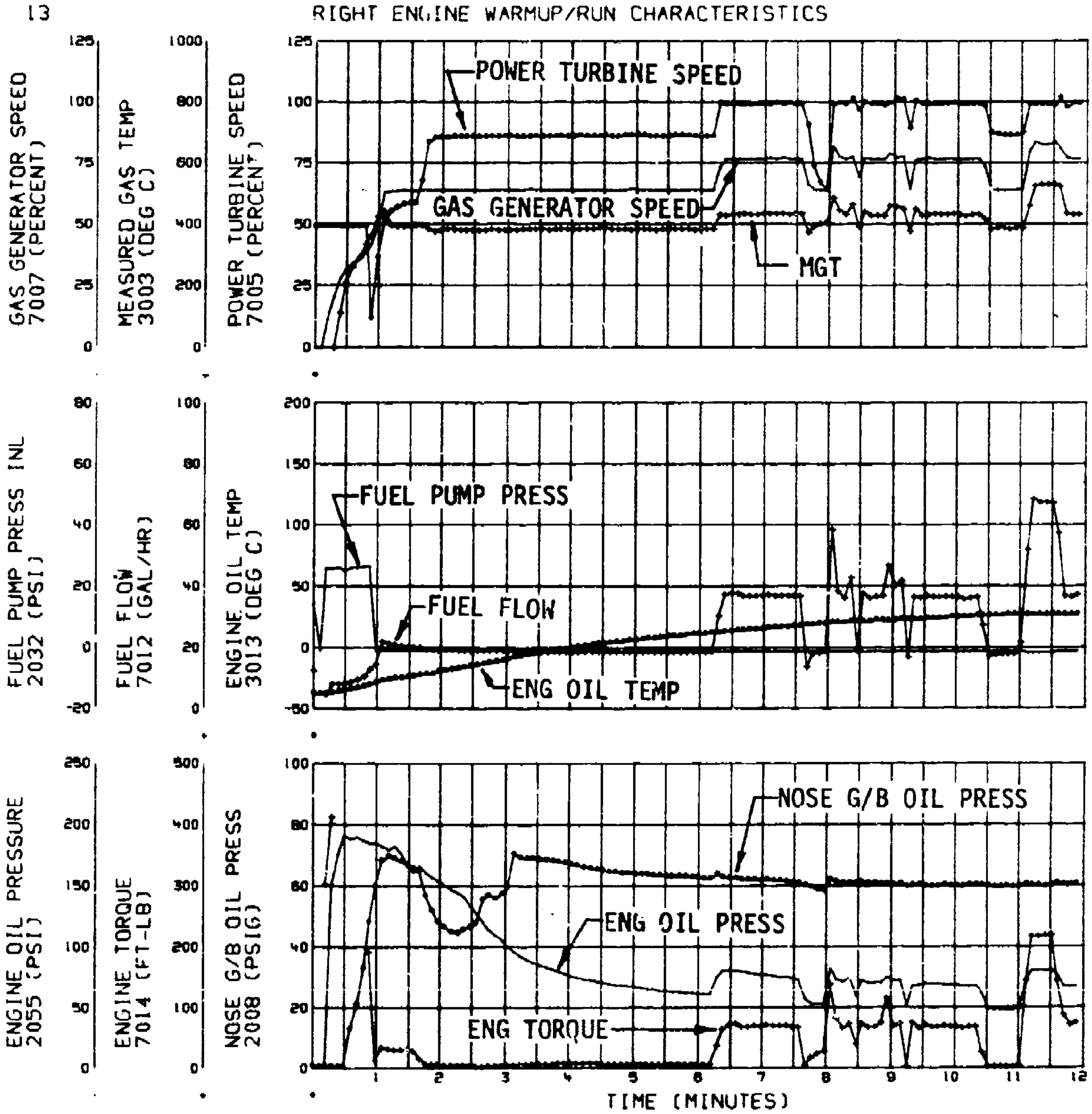


FIGURE 33
NO 2 ENGINE WARM-UP/RUN CHARACTERISTICS
T700-GE-700R ENGINE S/N 207-241R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125^{o}F

NOTES: 1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED

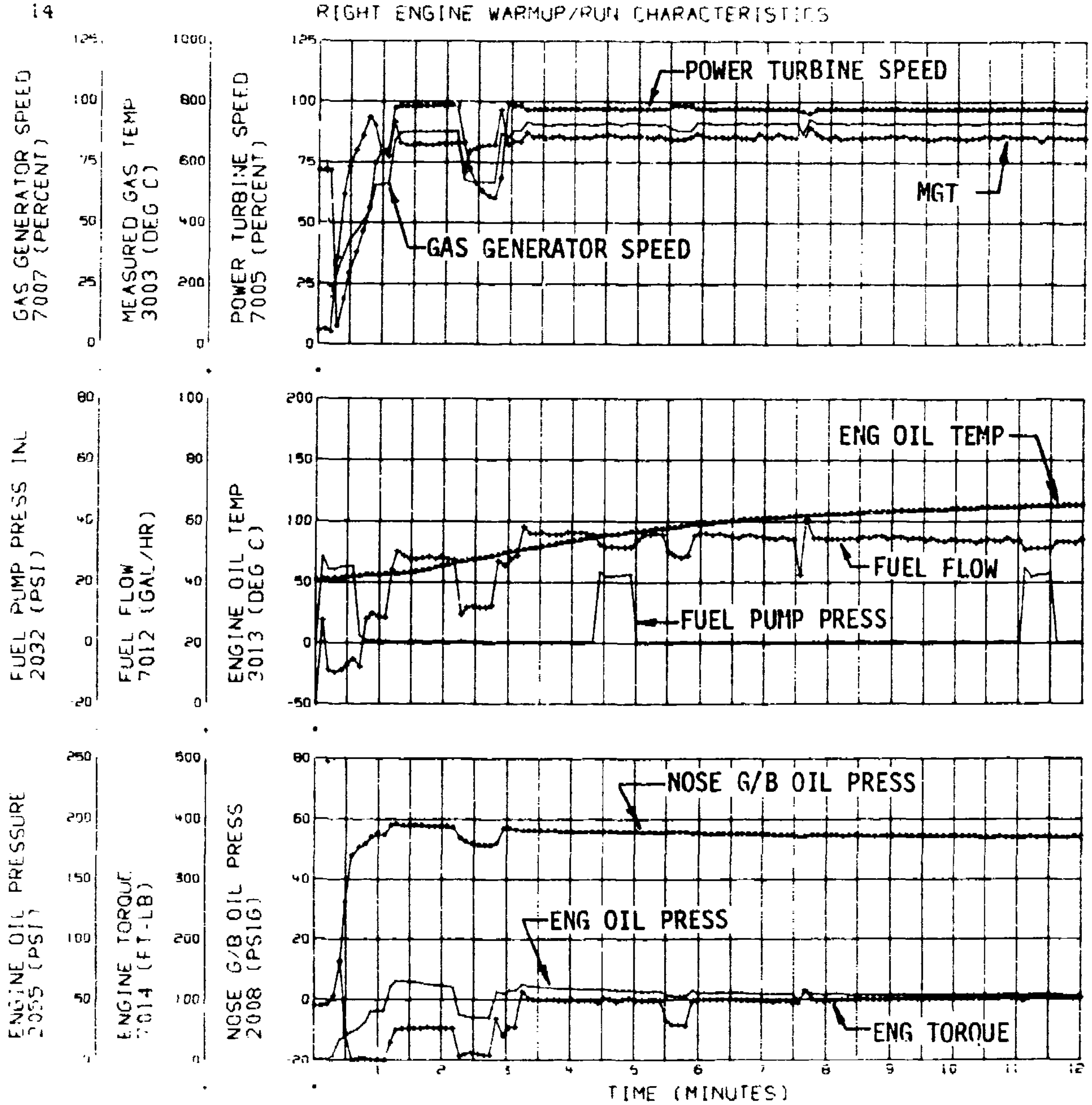


FIGURE 34

NO 1 ENGINE TEMPERATURE SURVEY

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED

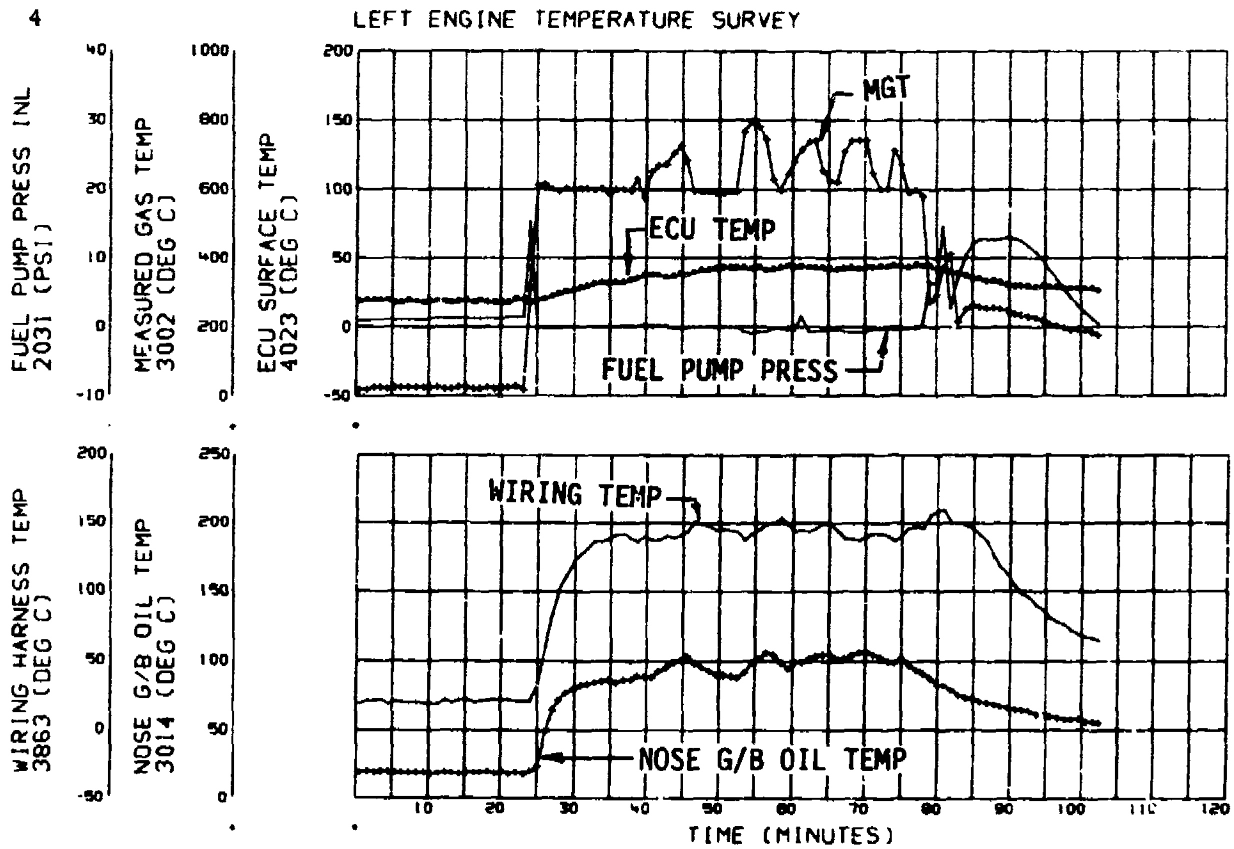


FIGURE 35

NO 1 ENGINE TEMPERATURE SURVEY

T700-GE-700R ENGINE S/N 207-263R

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-23699C OIL
2. JP-5 FUEL UTILIZED
3. NOSE GEAR BOX OIL TEMPERATURE INSTRUMENTATION FAILED

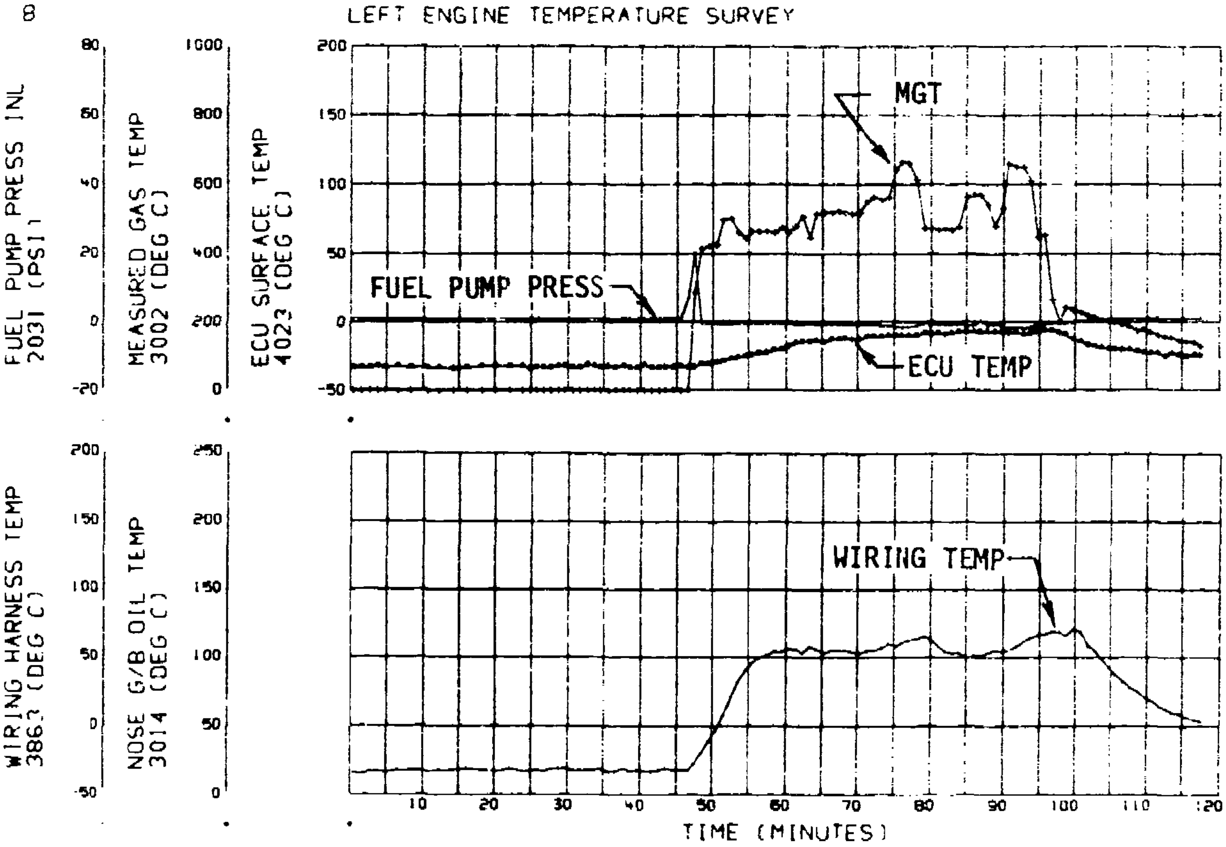


FIGURE 36

NO 1 ENGINE TEMPERATURE SURVEY

T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. NOSE GEARBOX OIL TEMPERATURE INSTRUMENTATION FAILED

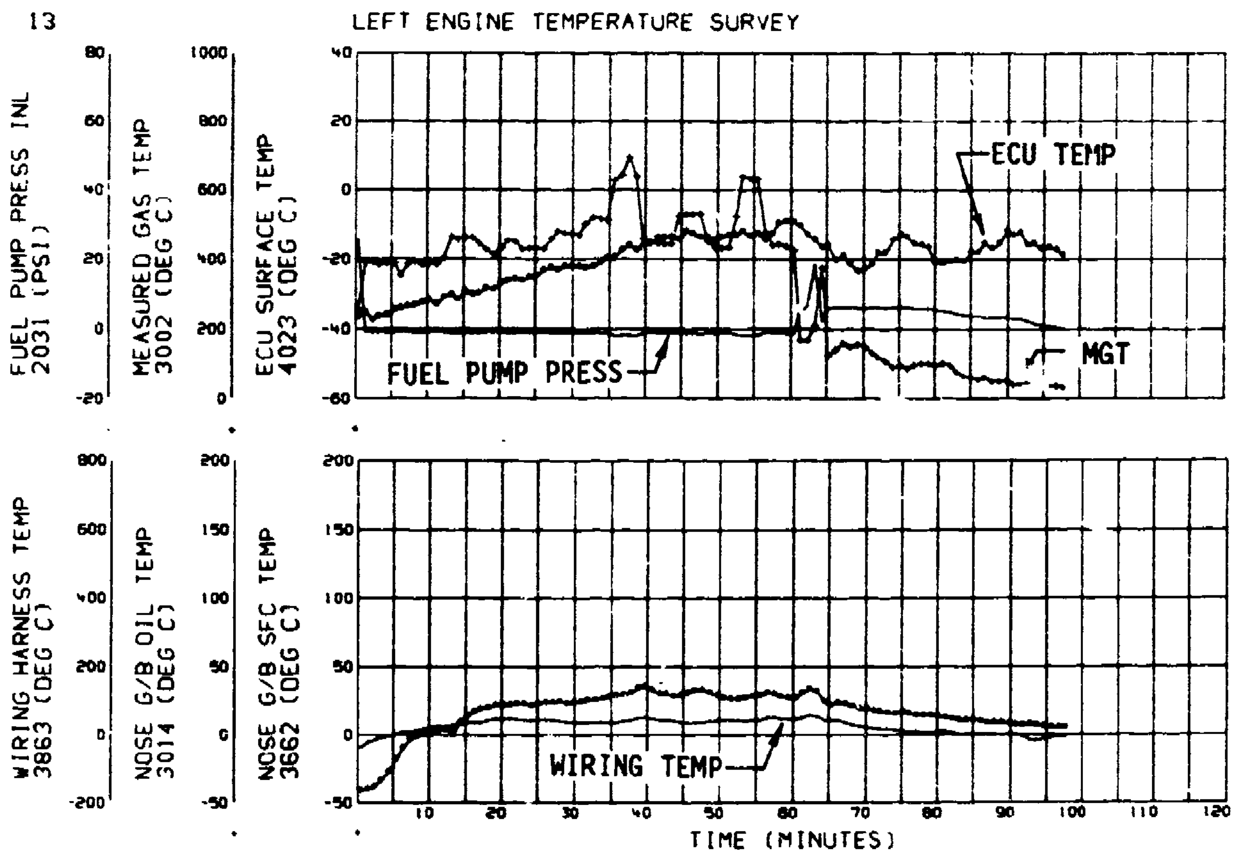


FIGURE 37
NO 1 ENGINE TEMPERATURE SURVEY
T700-GE-700R ENGINE S/N 207-263R
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. ENGINE SERVICED WITH MIL-L-7808H OIL
2. JP-4 FUEL UTILIZED
3. NOSE GEARBOX OIL TEMPERATURE INSTRUMENTATION FAILED

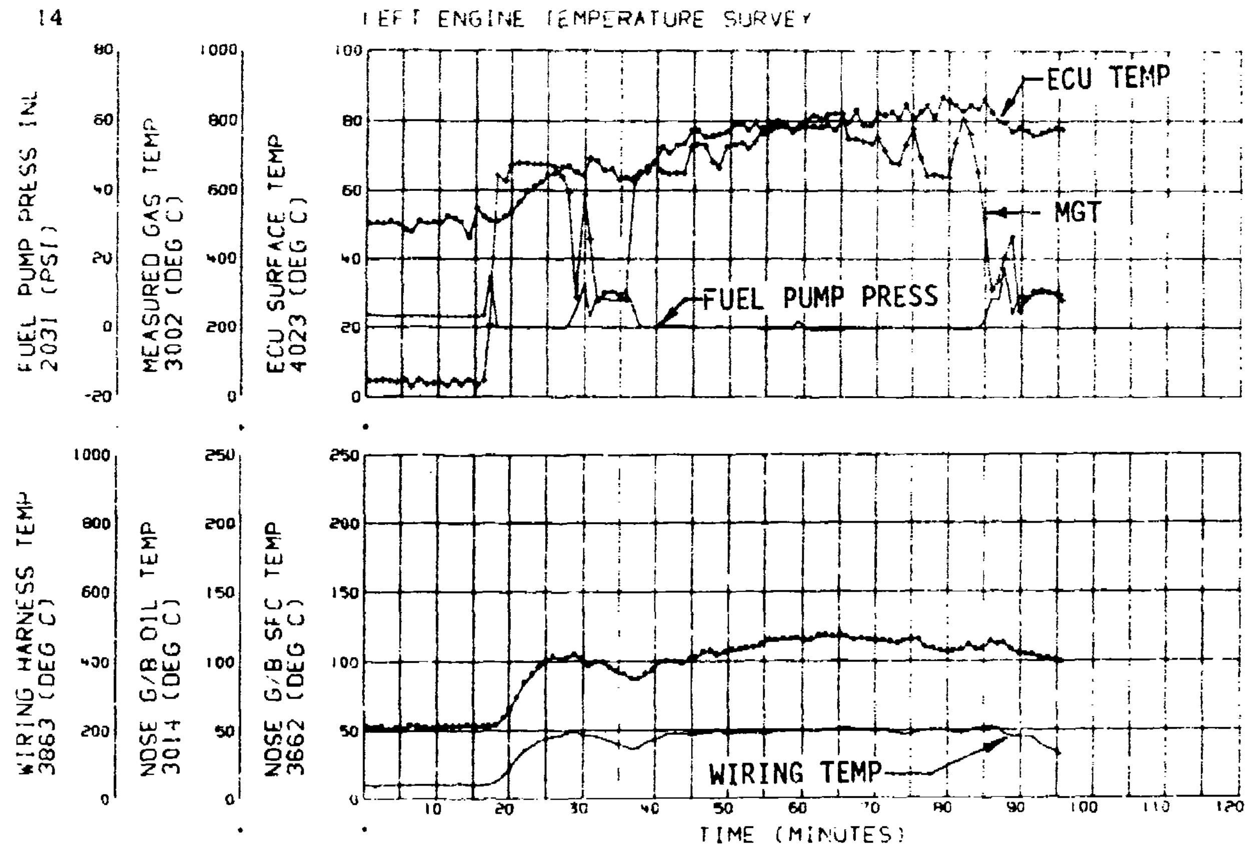


FIGURE 38
CABIN AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

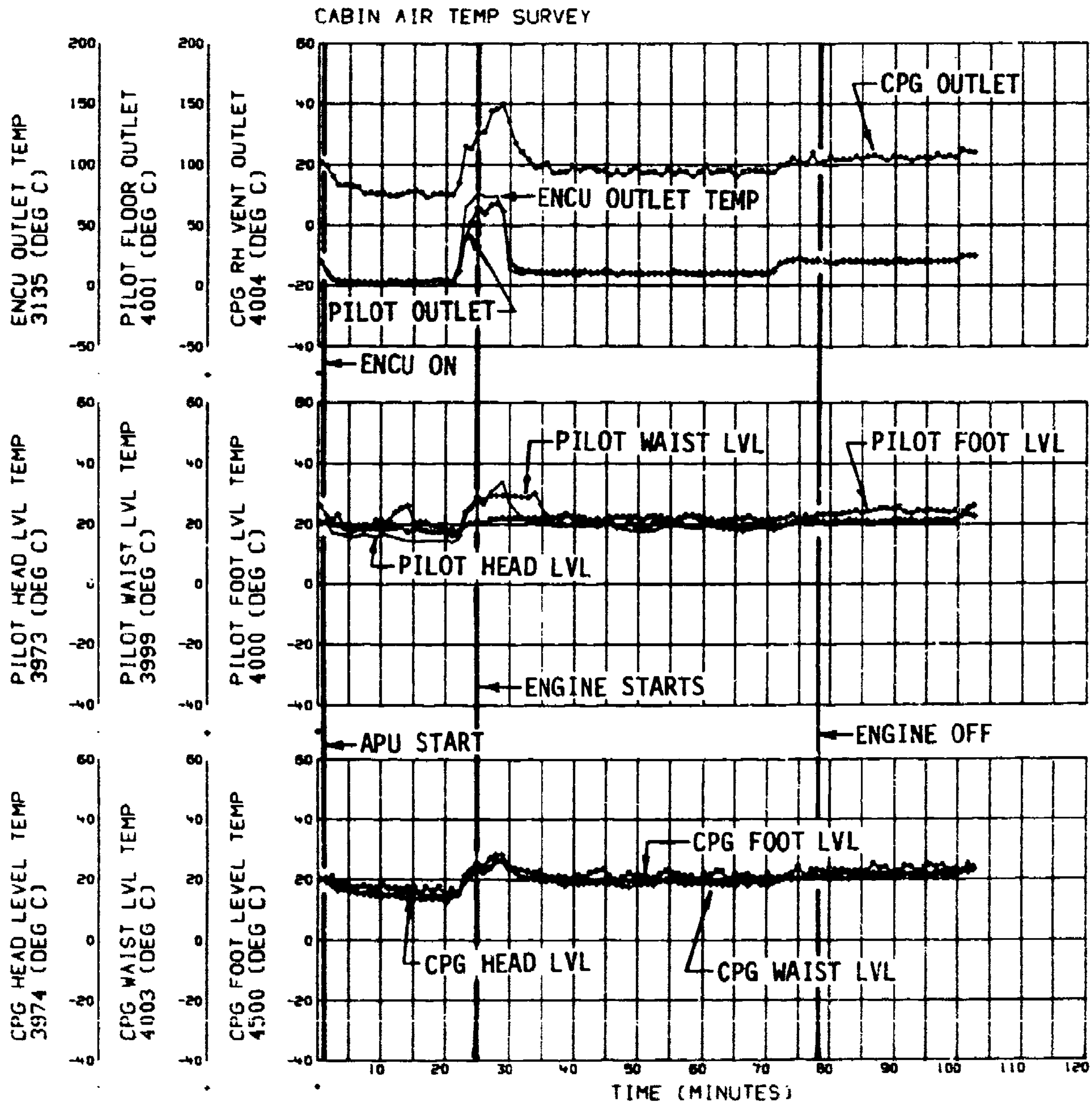


FIGURE 39
CABIN AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

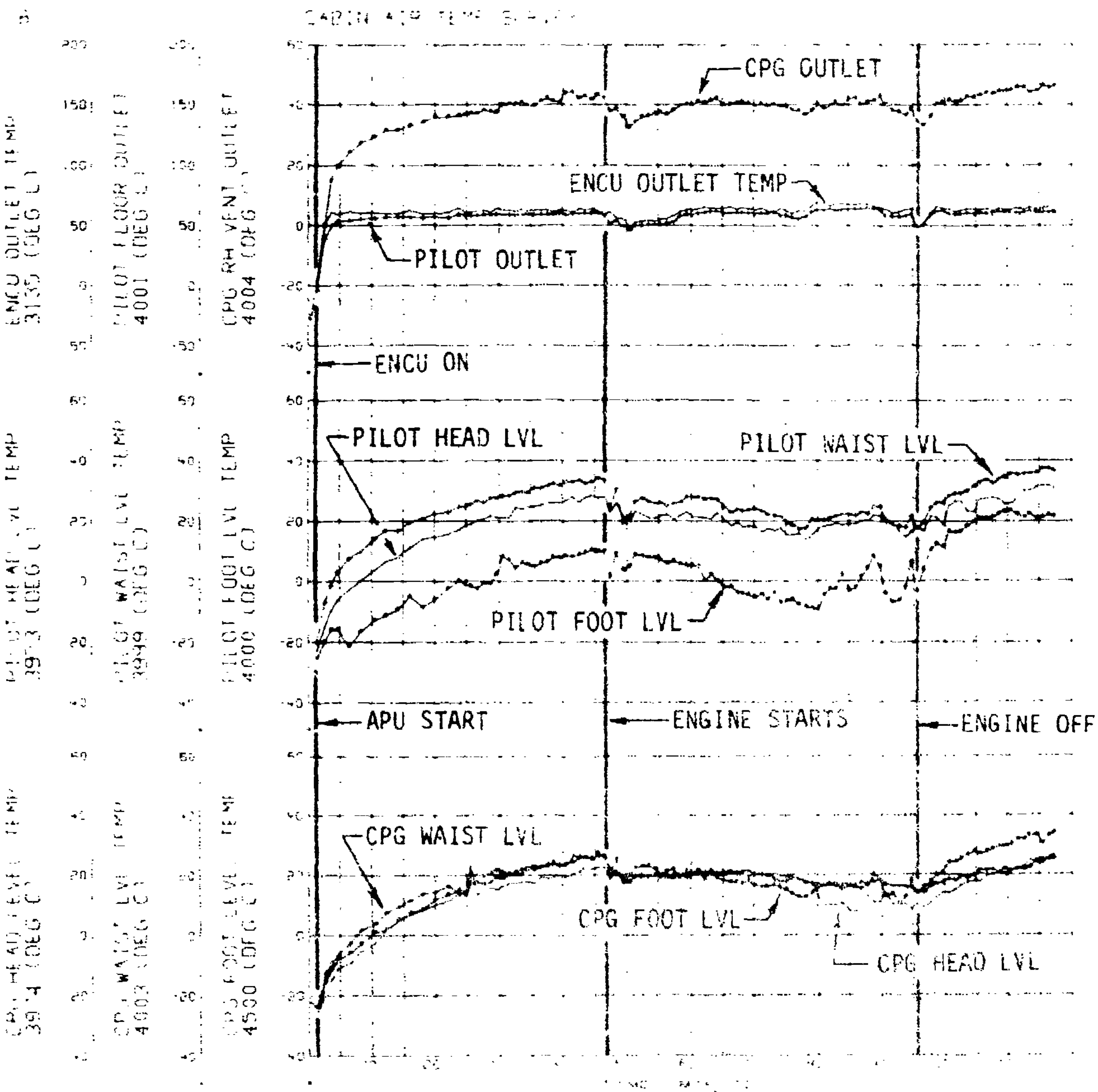


FIGURE 40
CABIN AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

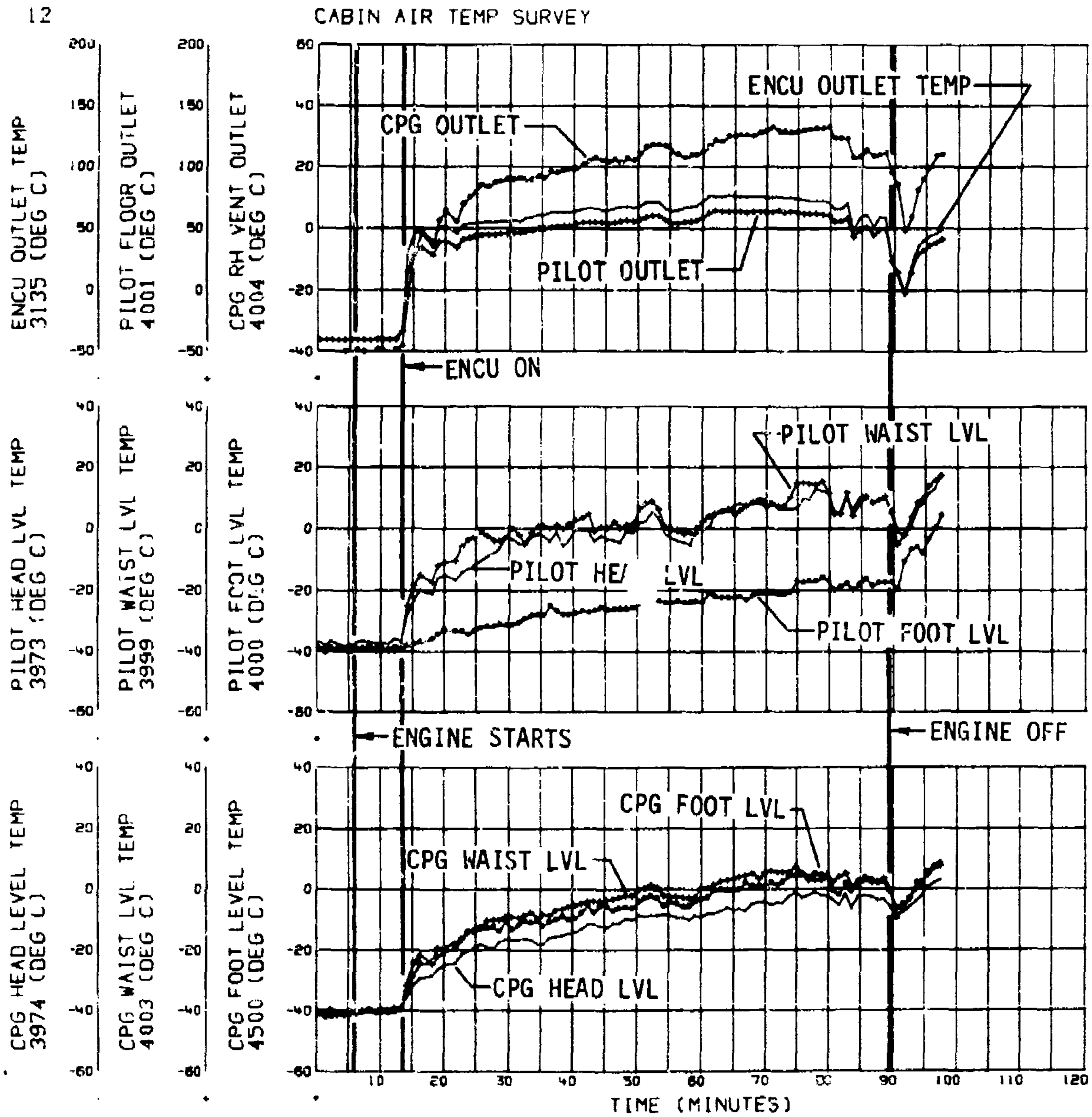


FIGURE 41
CABIN AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

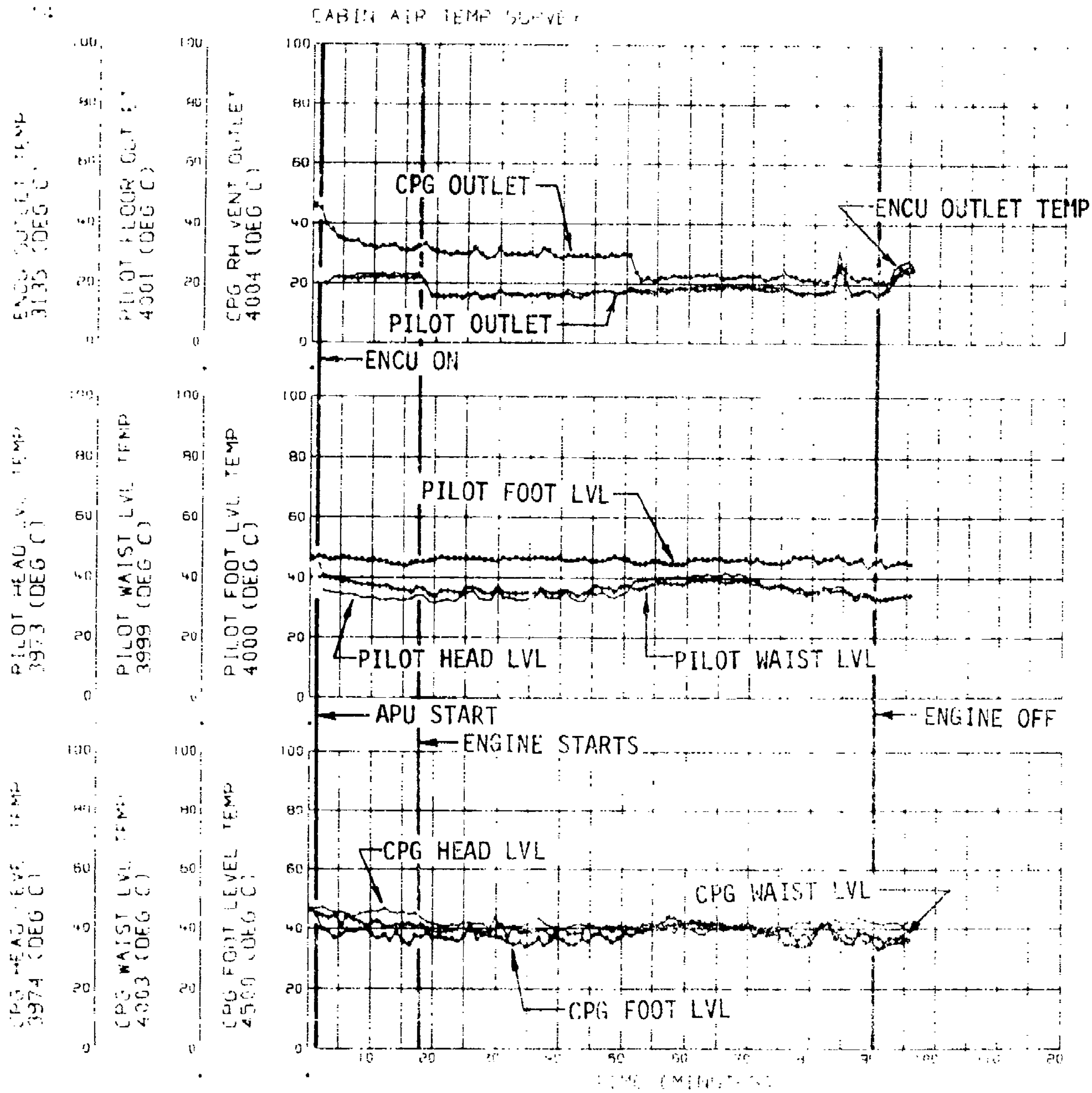


FIGURE 42
AVIONICS AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

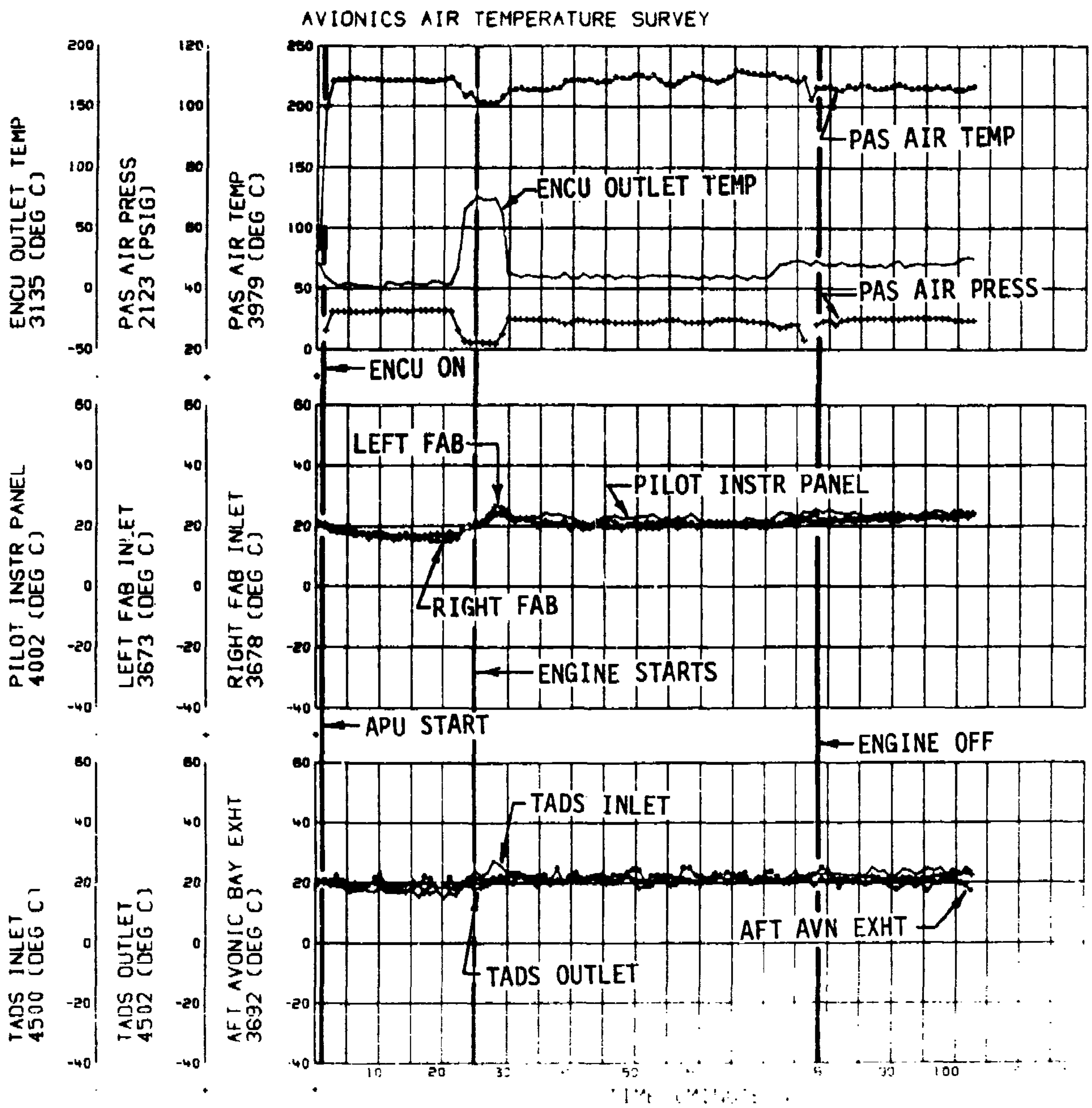


FIGURE 43
AVIONICS AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22248
CLIMATIC LABORATORY TEMPERATURE -25°F

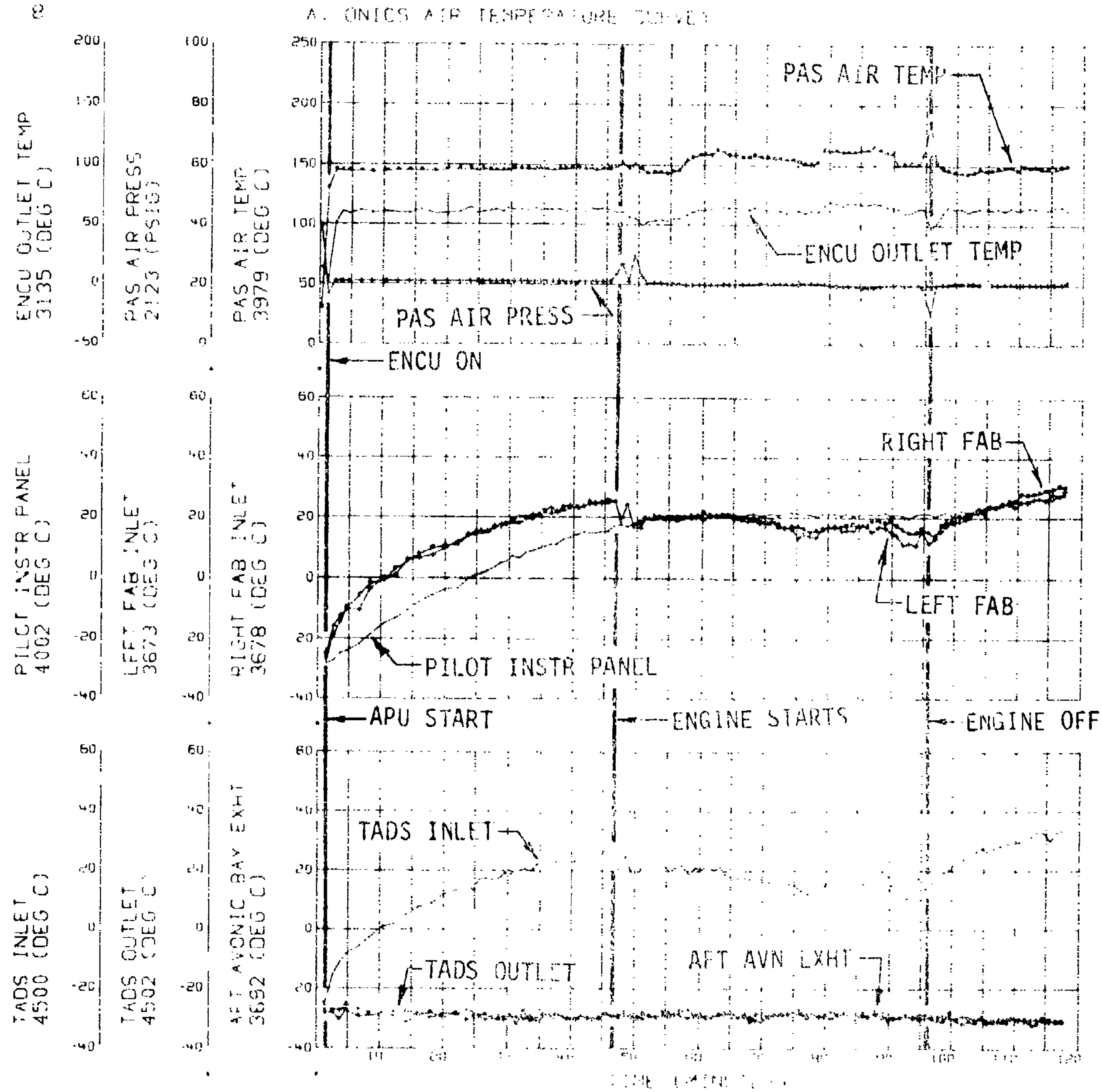


FIGURE 44
AVIONICS AIR TEMPERATURE SURVEY

YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTE: TADS OUTLET TEMPERATURE INSTRUMENTATION FAILED

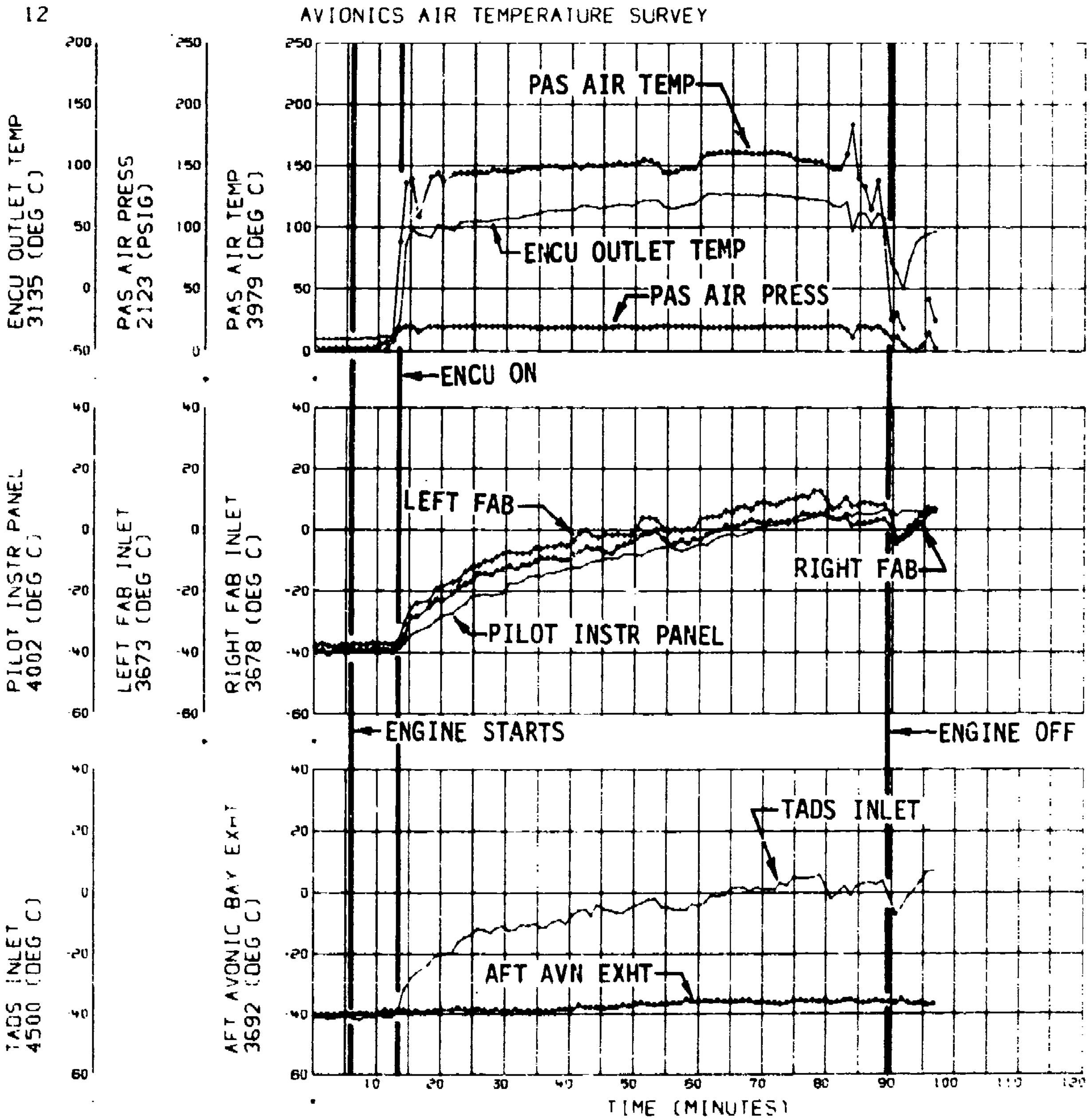


FIGURE 45
AVIONICS AIR TEMPERATURE SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTE: TADS OUTLET TEMPERATURE INSTRUMENTATION FAILED

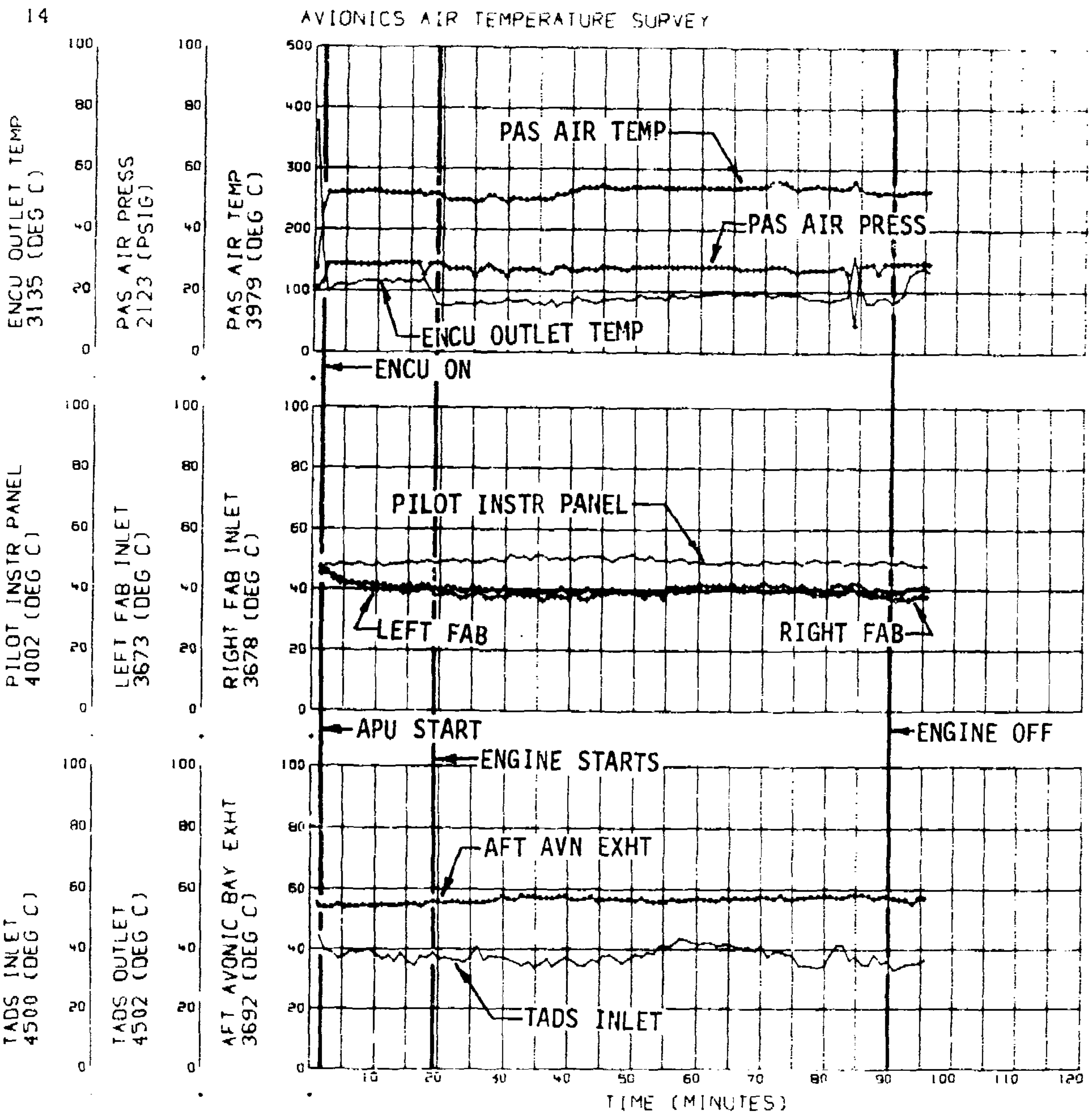


FIGURE 46

ELECTRICAL SYSTEM SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70° F

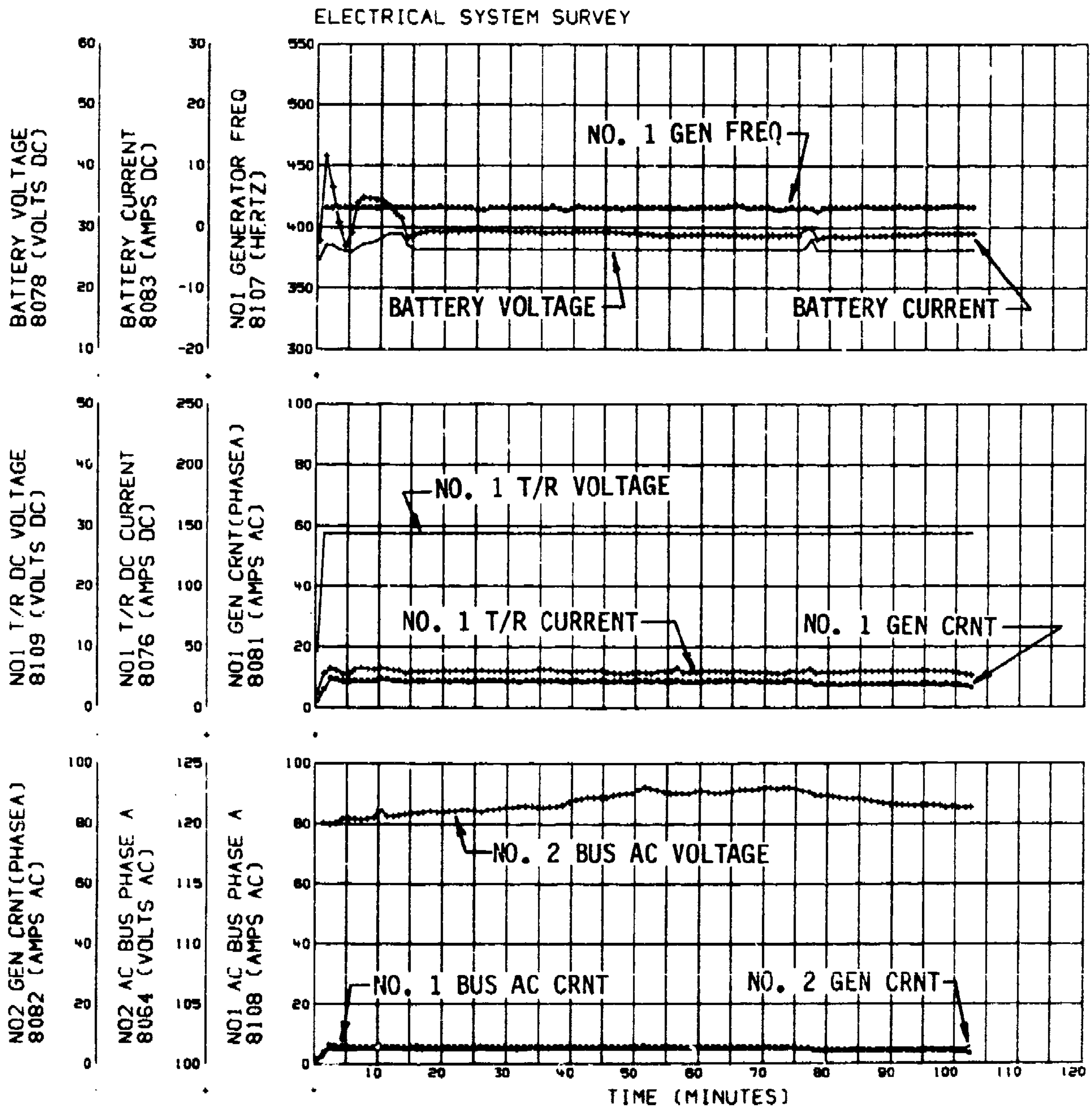


FIGURE 47

ELECTRICAL SYSTEM SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

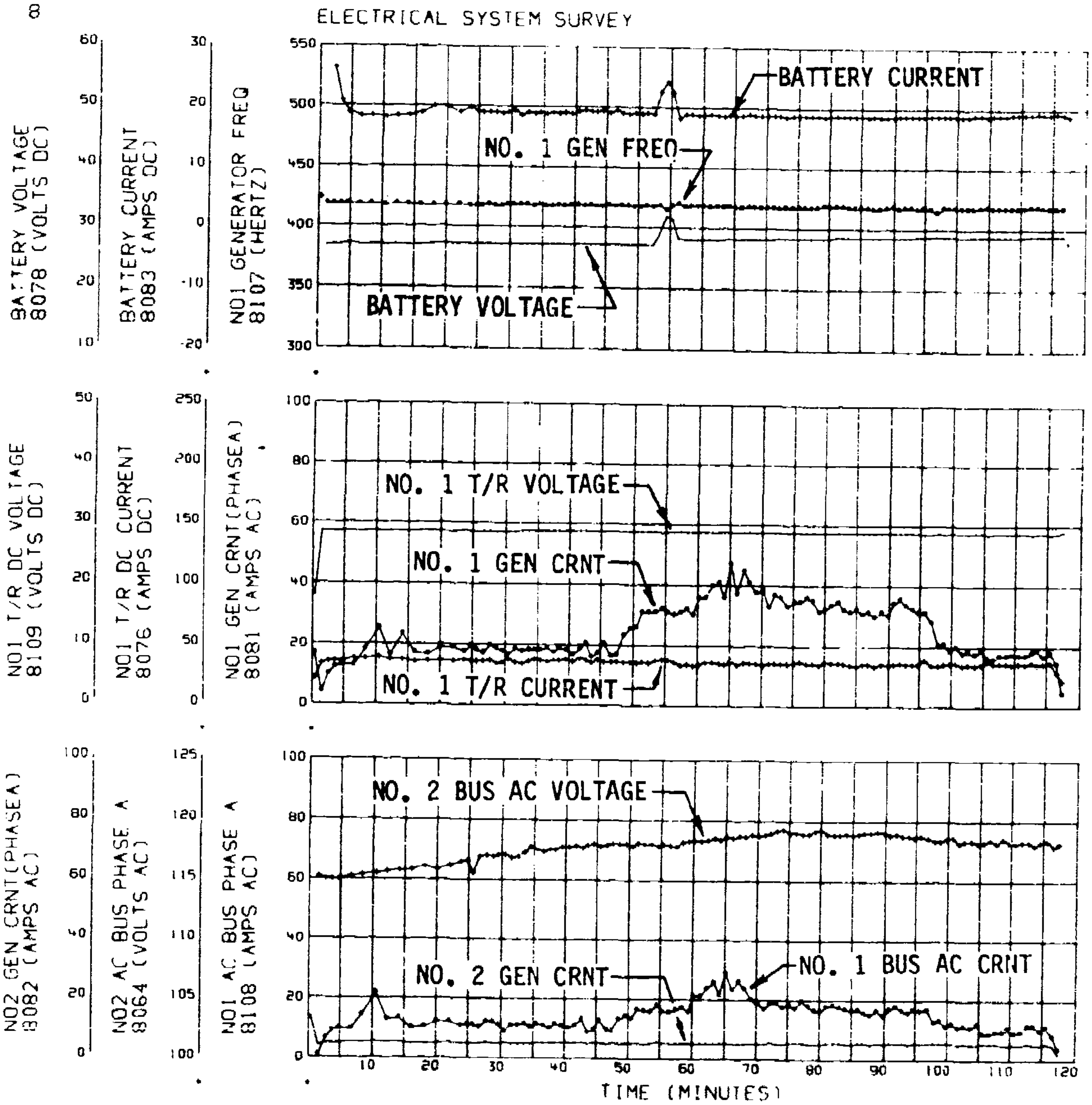


FIGURE 48
ELECTRICAL SYSTEM SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

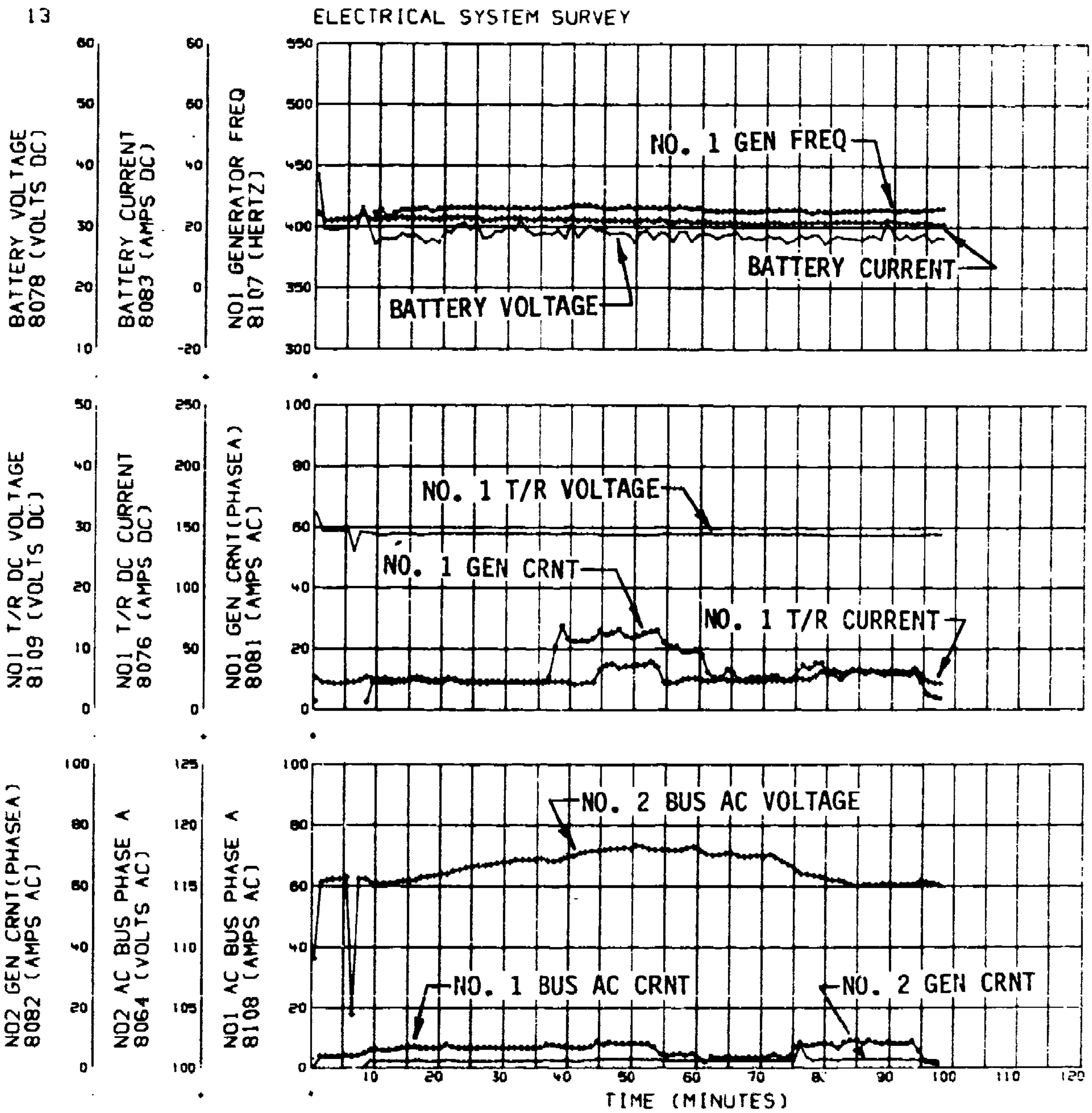


FIGURE 49
ELECTRICAL SYSTEM SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

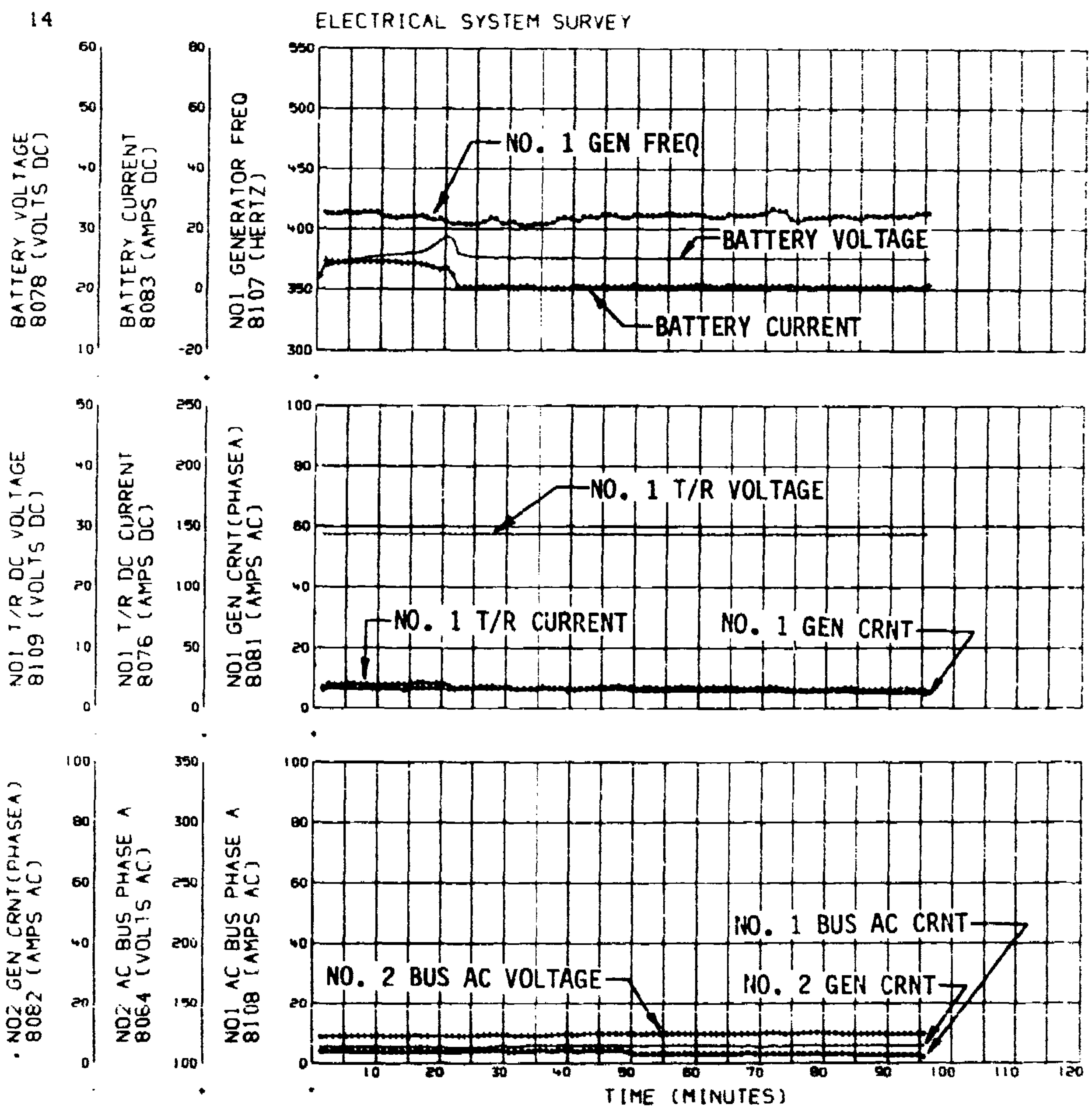


FIGURE 50

PRIMARY HYDRAULIC SYSTEM SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

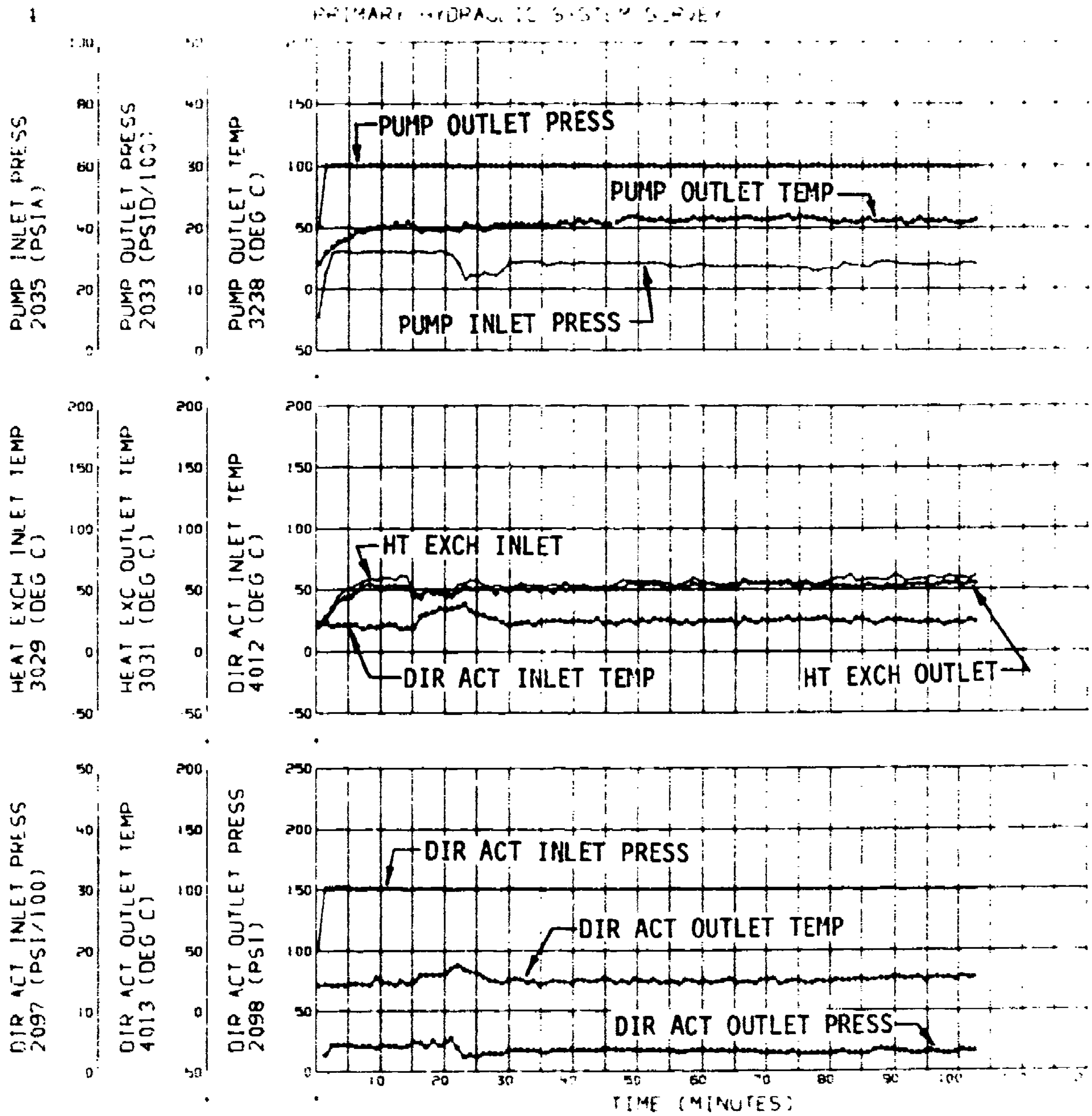


FIGURE 51
PRIMARY HYDRAULIC SYSTEM SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

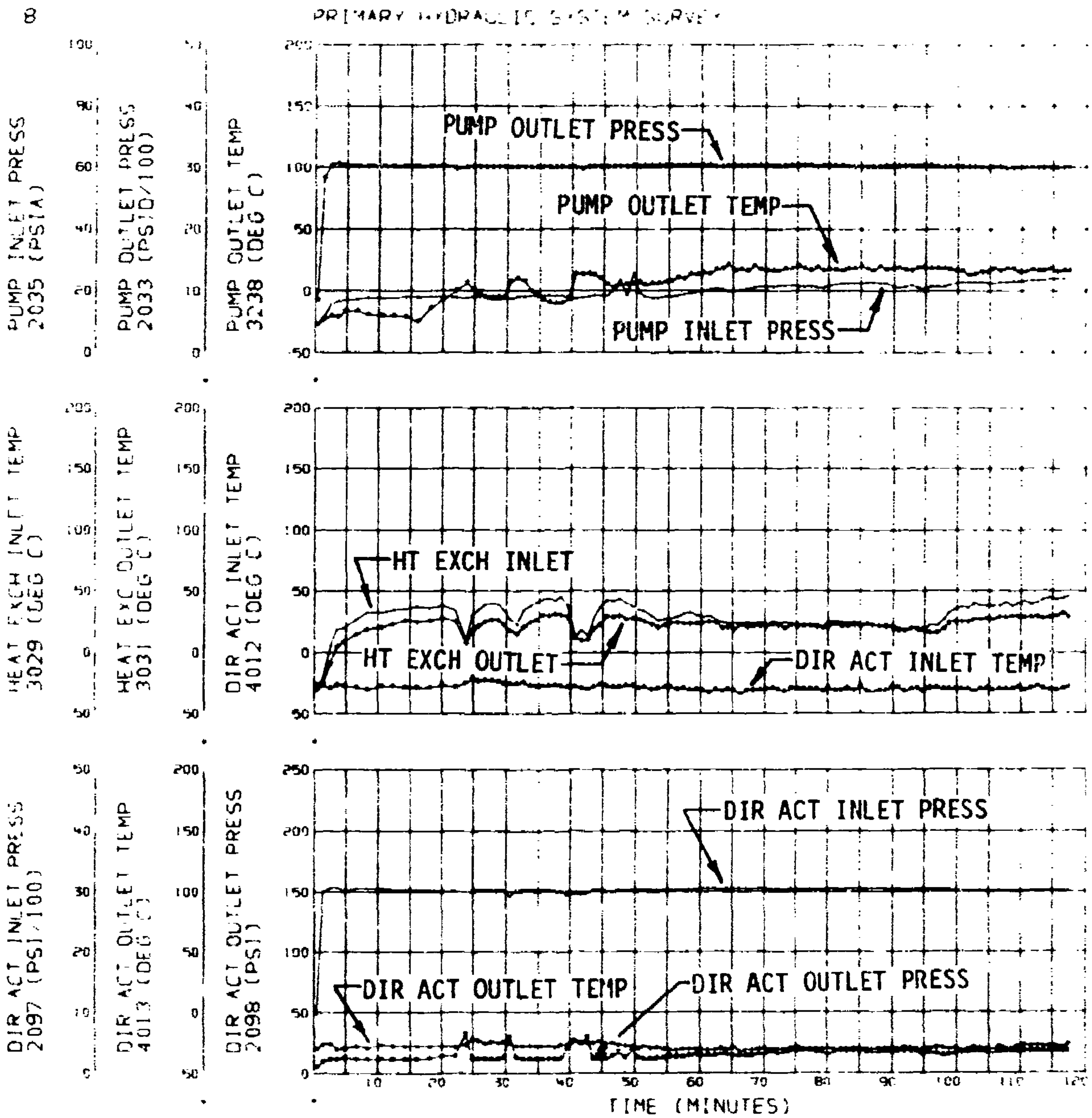


FIGURE 52
PRIMARY HYDRAULIC SYSTEM SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID

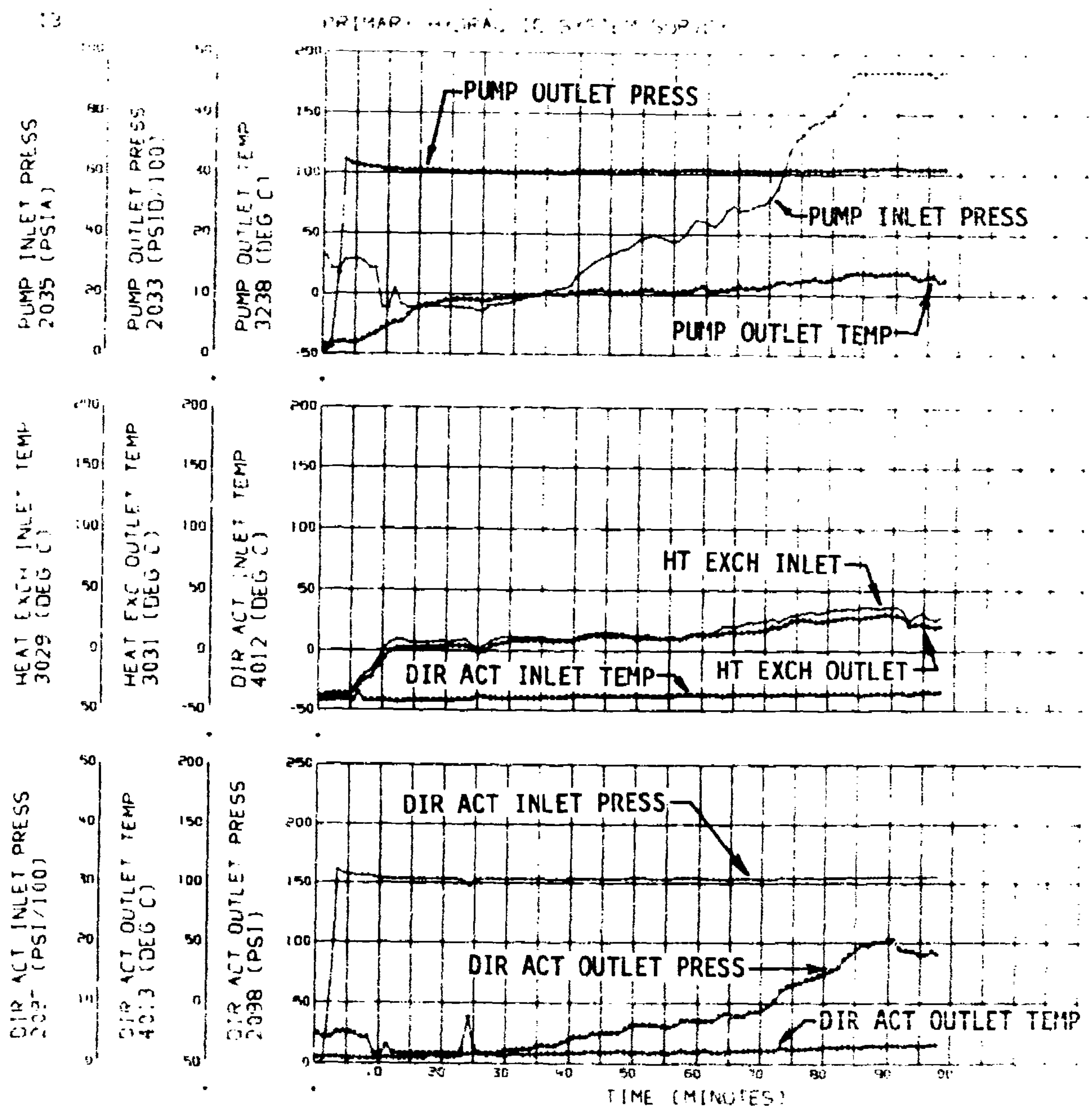


FIGURE 53
PRIMARY HYDRAULIC SYSTEM SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID

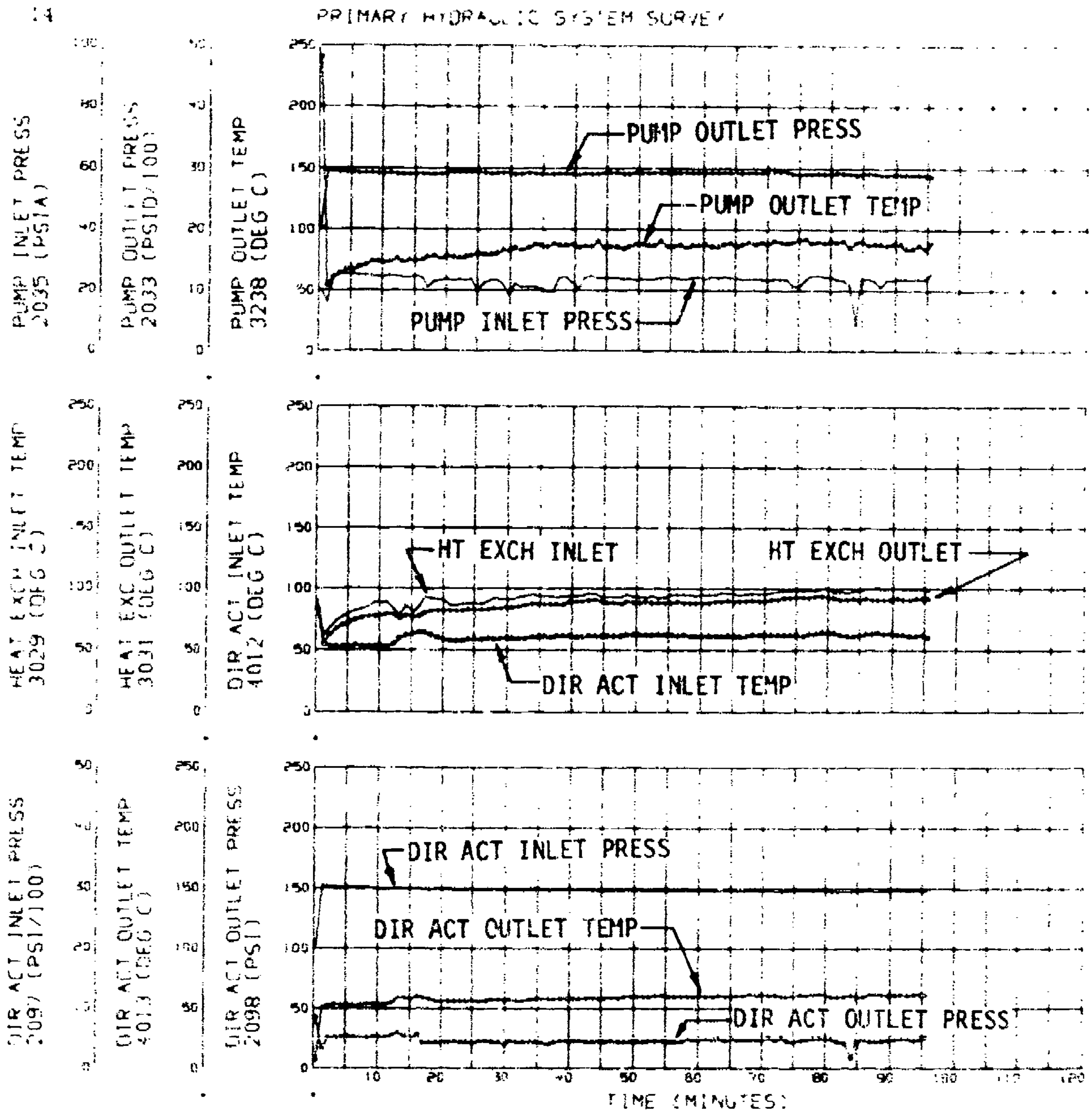


FIGURE 54
UTILITY HYDRAULIC SYSTEM SURVEY - A
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

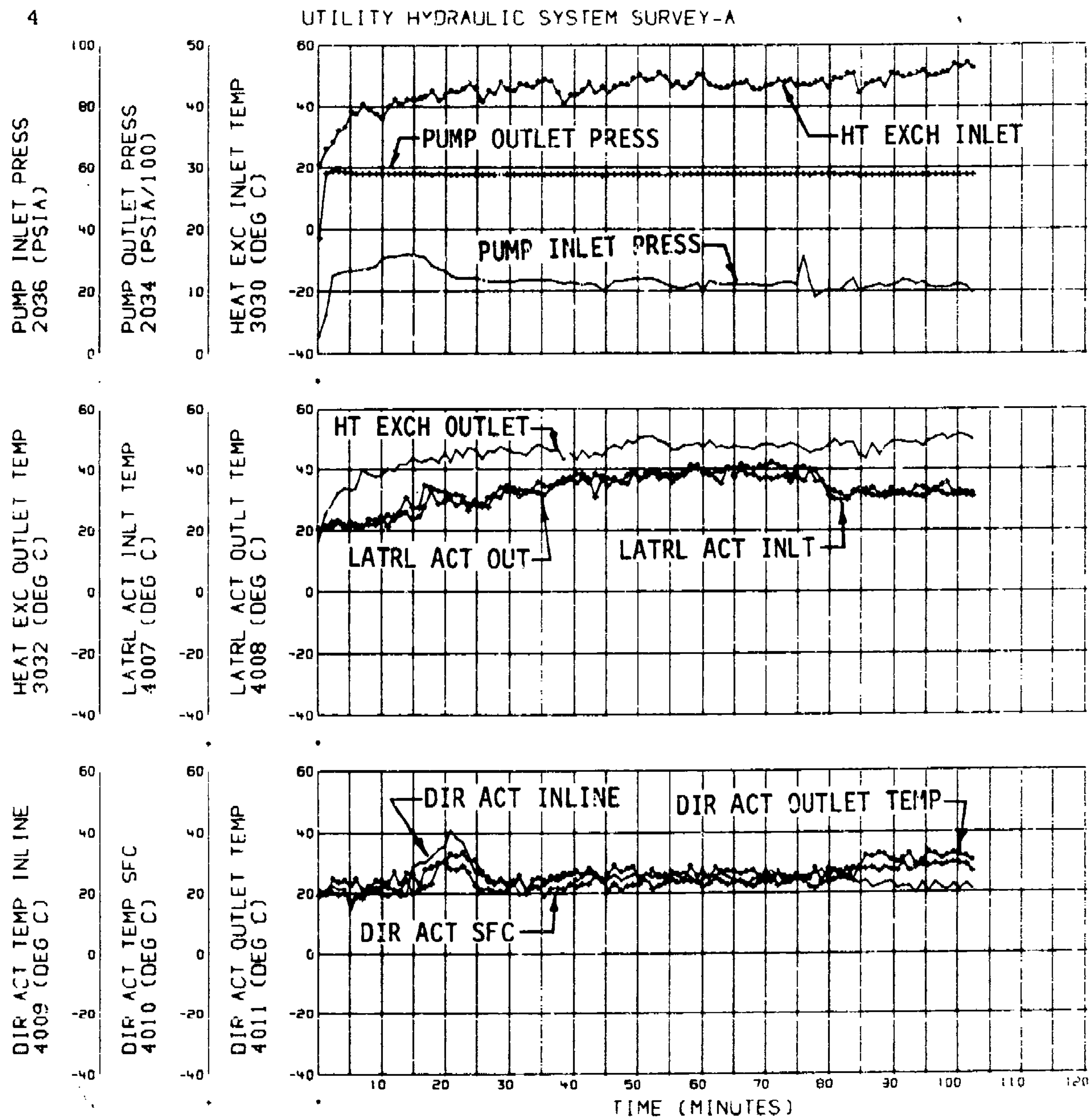


FIGURE 55
UTILITY HYDRAULIC SYSTEM SURVEY - B
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70° F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

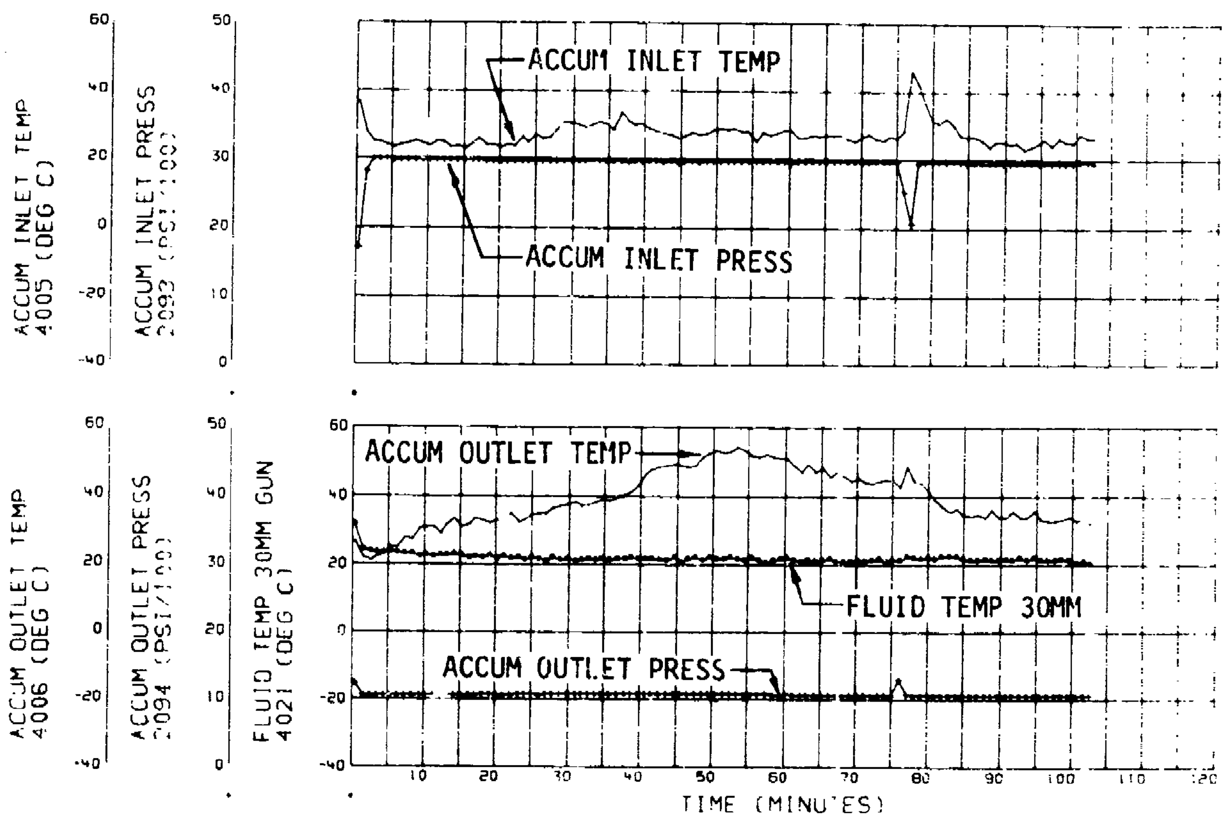


FIGURE 56
UTILITY HYDRAULIC SYSTEM SURVEY - A
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

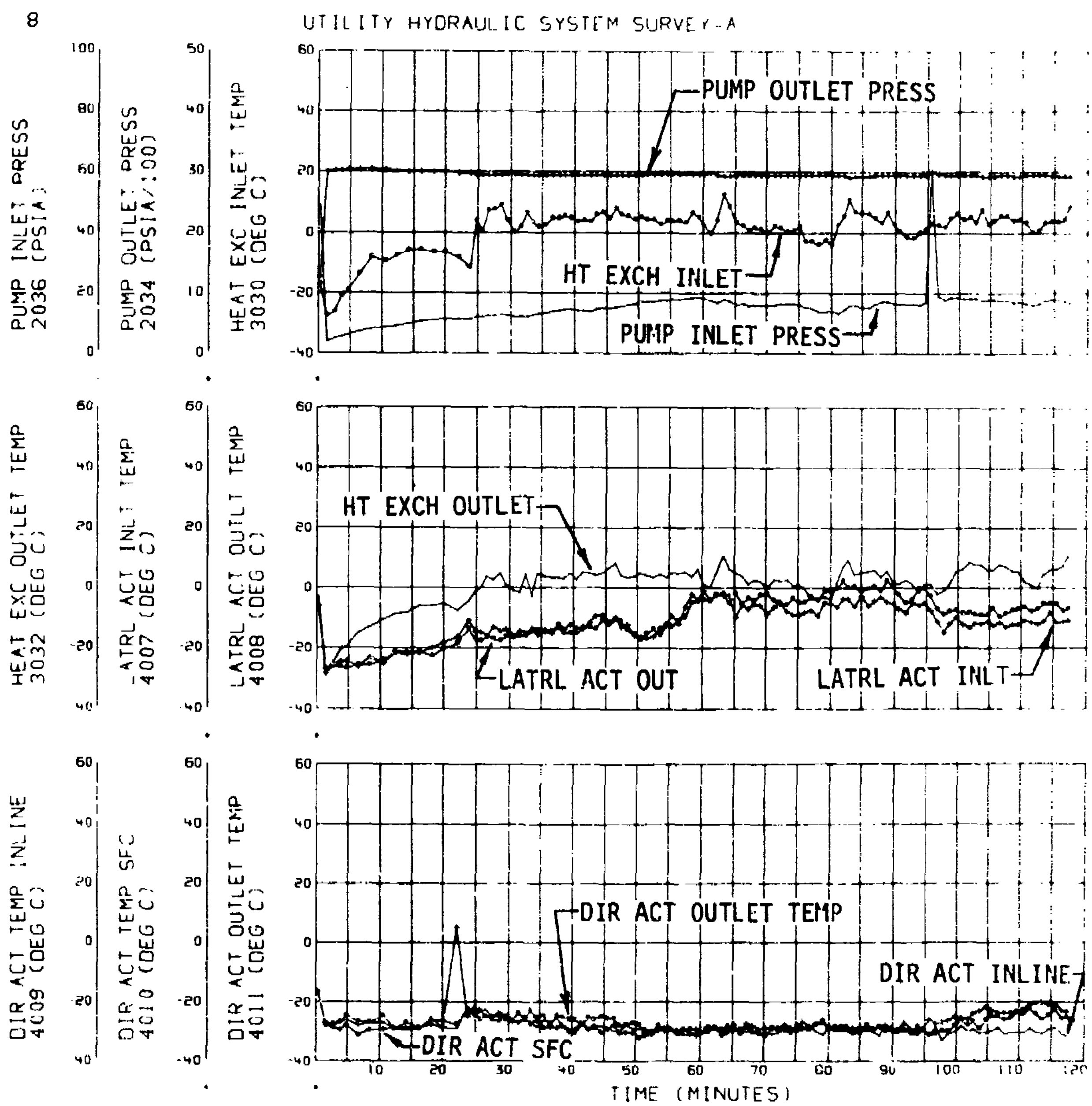


FIGURE 57

UTILITY HYDRAULIC SYSTEM SURVEY - B

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-83282A FLUID

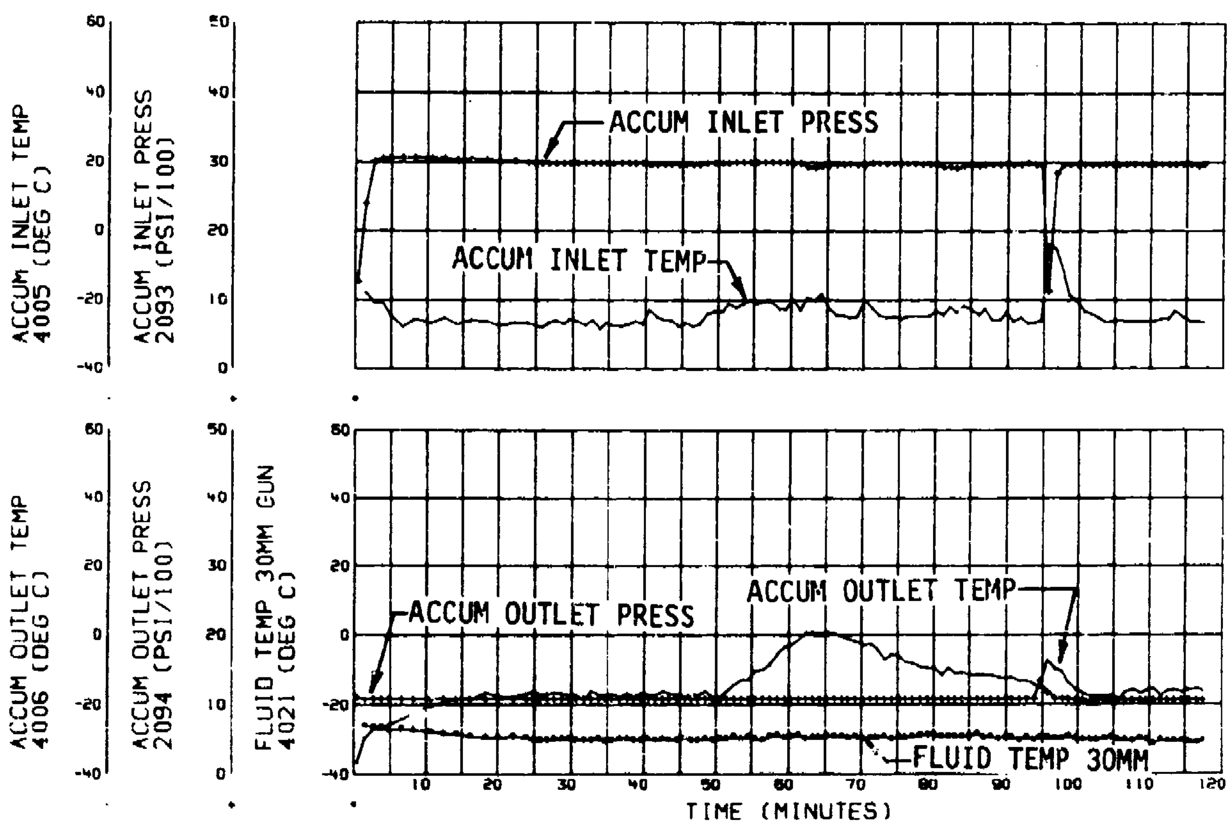


FIGURE 58
UTILITY HYDRAULIC SYSTEM SURVEY - A

YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID

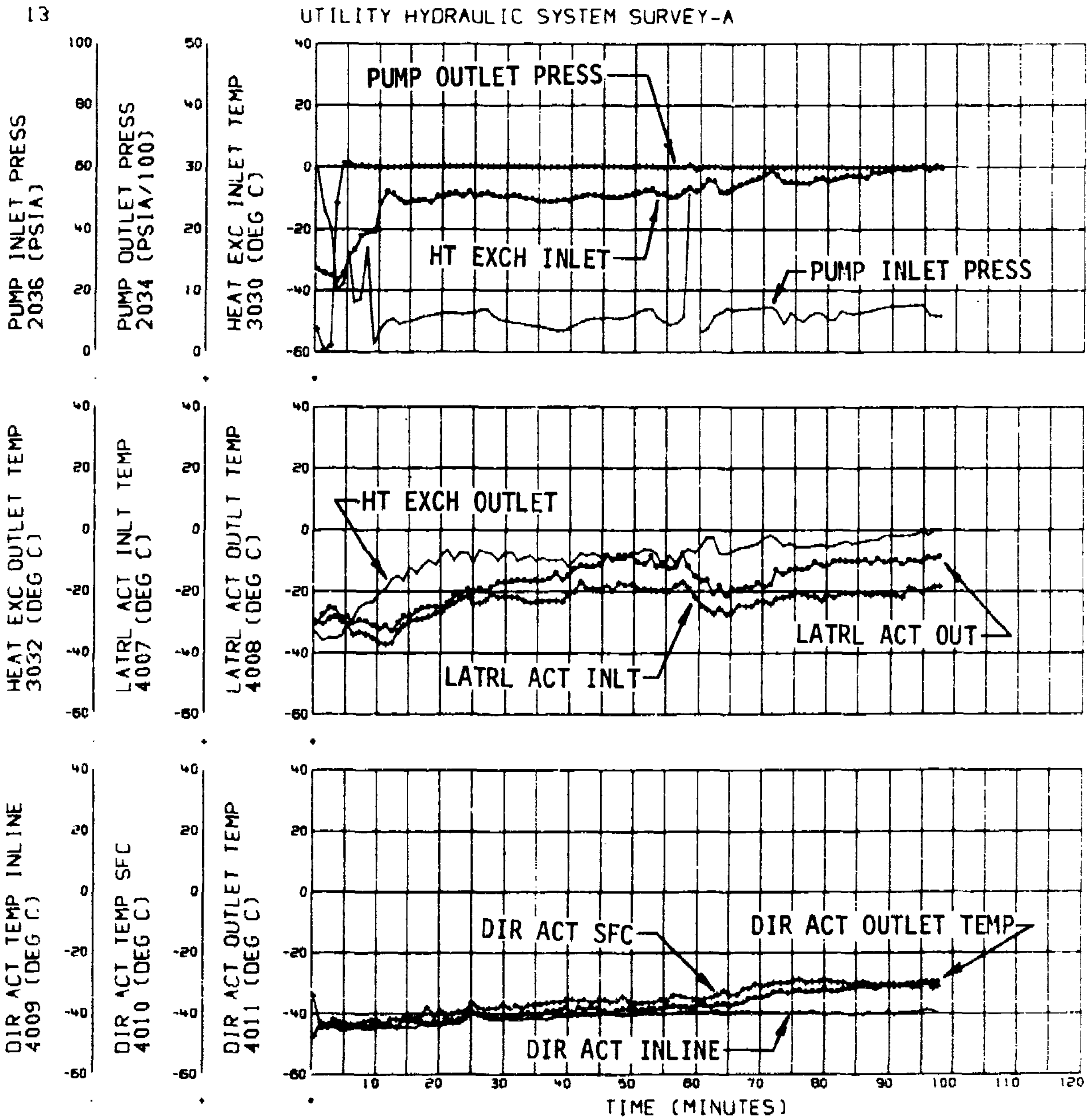


FIGURE 59
UTILITY HYDRAULIC SYSTEM SURVEY - B
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -50°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID

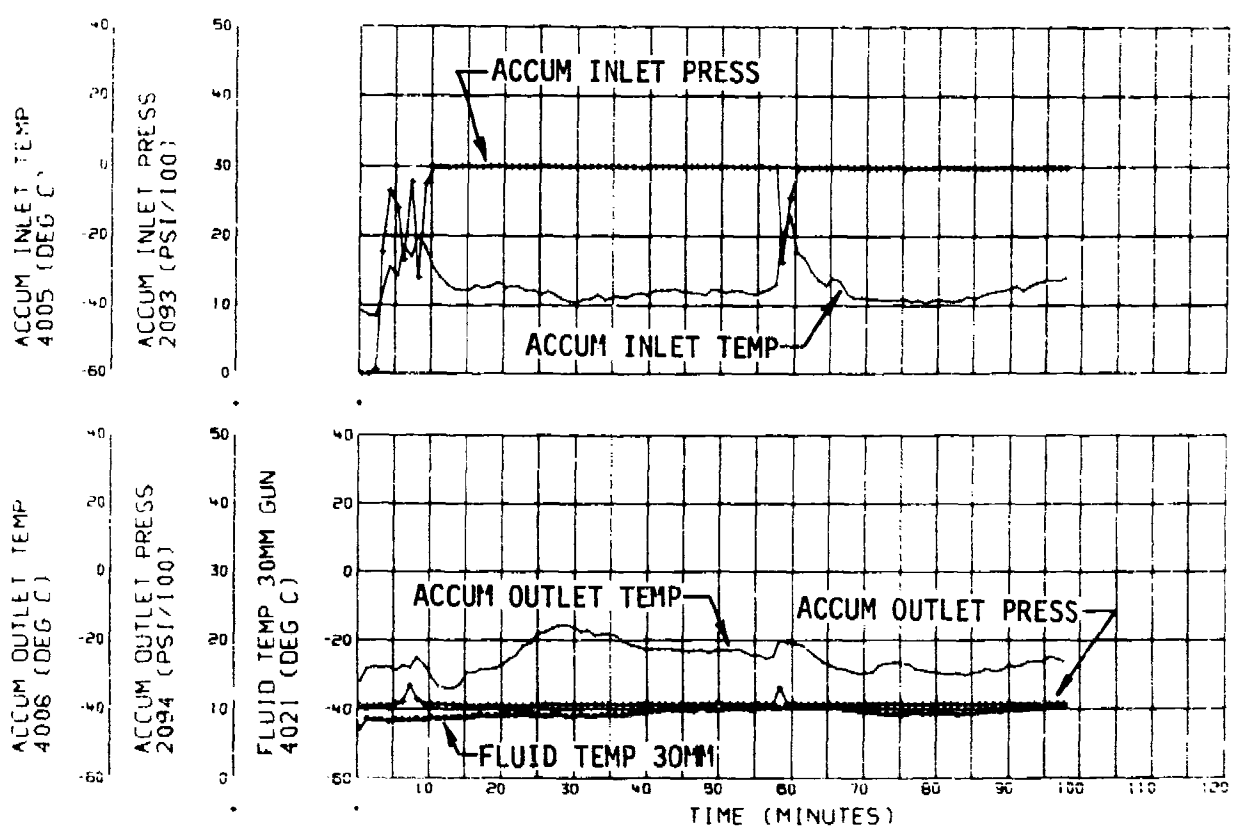


FIGURE 60

UTILITY HYDRAULIC SYSTEM SURVEY - A

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTE: HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID

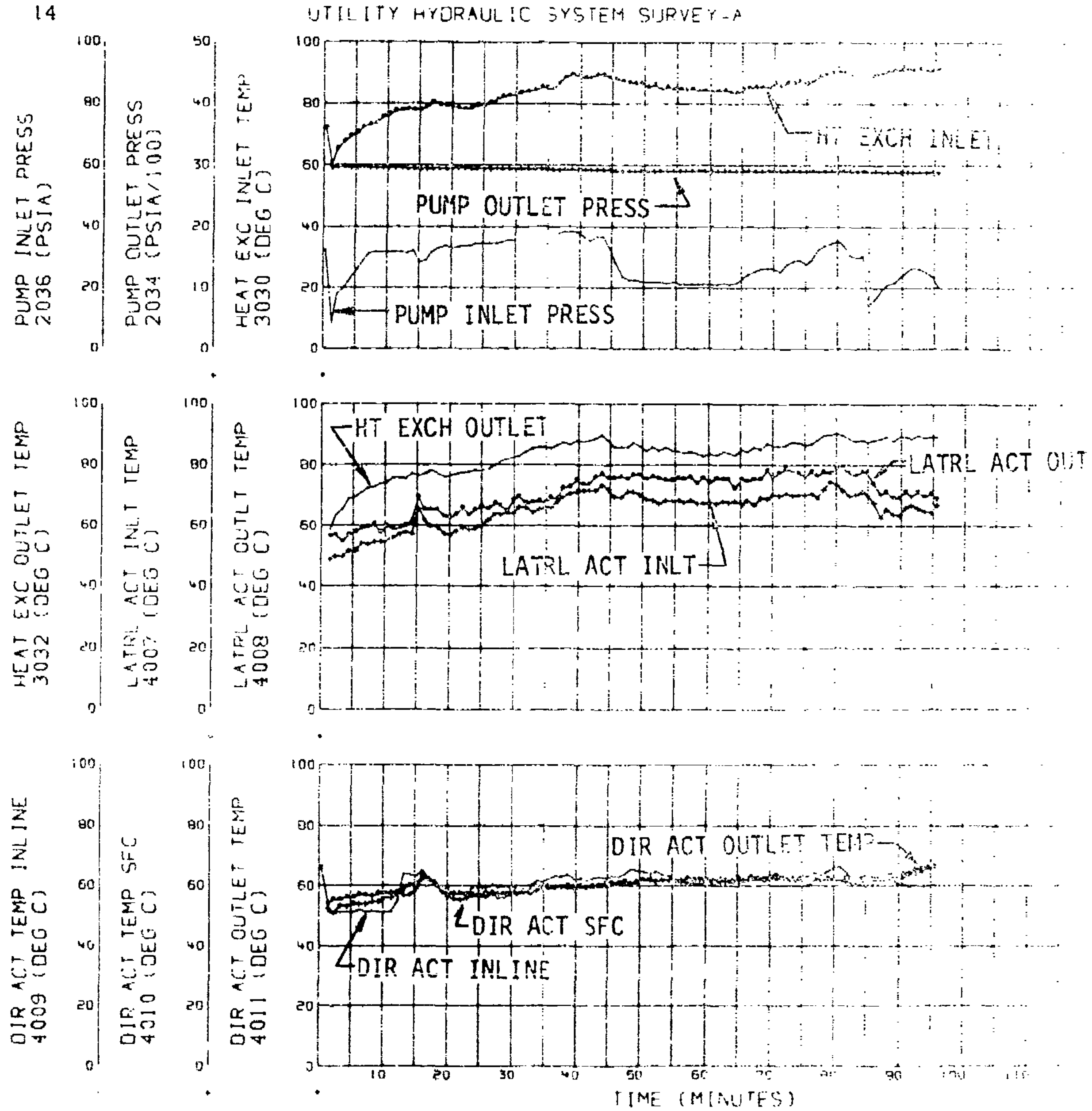


FIGURE 61

UTILITY HYDRAULIC SYSTEM SURVEY - B

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTE:
1. HYDRAULIC SYSTEM SERVICED WITH MIL-H-5606H FLUID
2. ACCUMULATOR OUTLET PRESSURE INSTRUMENTATION UNRELIABLE

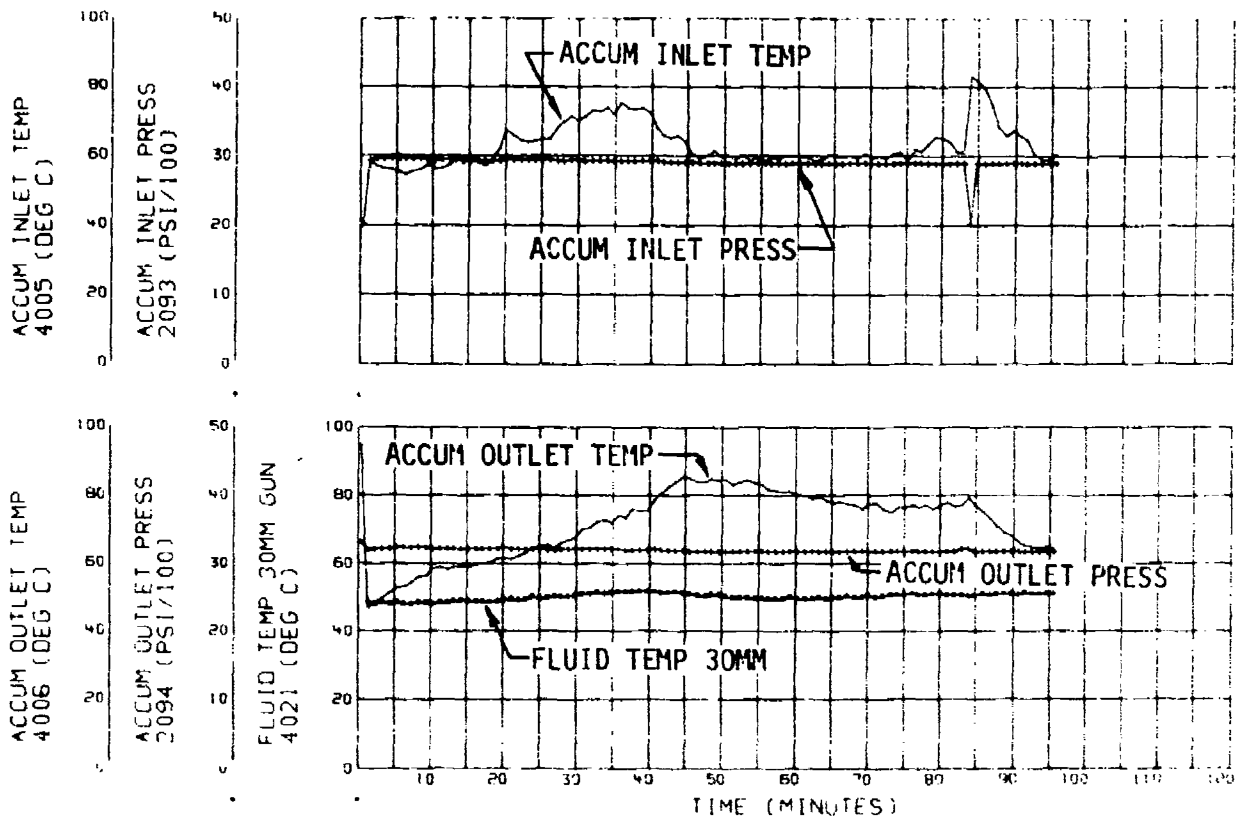


FIGURE 62

MAIN TRANSMISSION SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

NOTE: TRANSMISSIONS SERVICED WITH MIL-L-23699C OIL

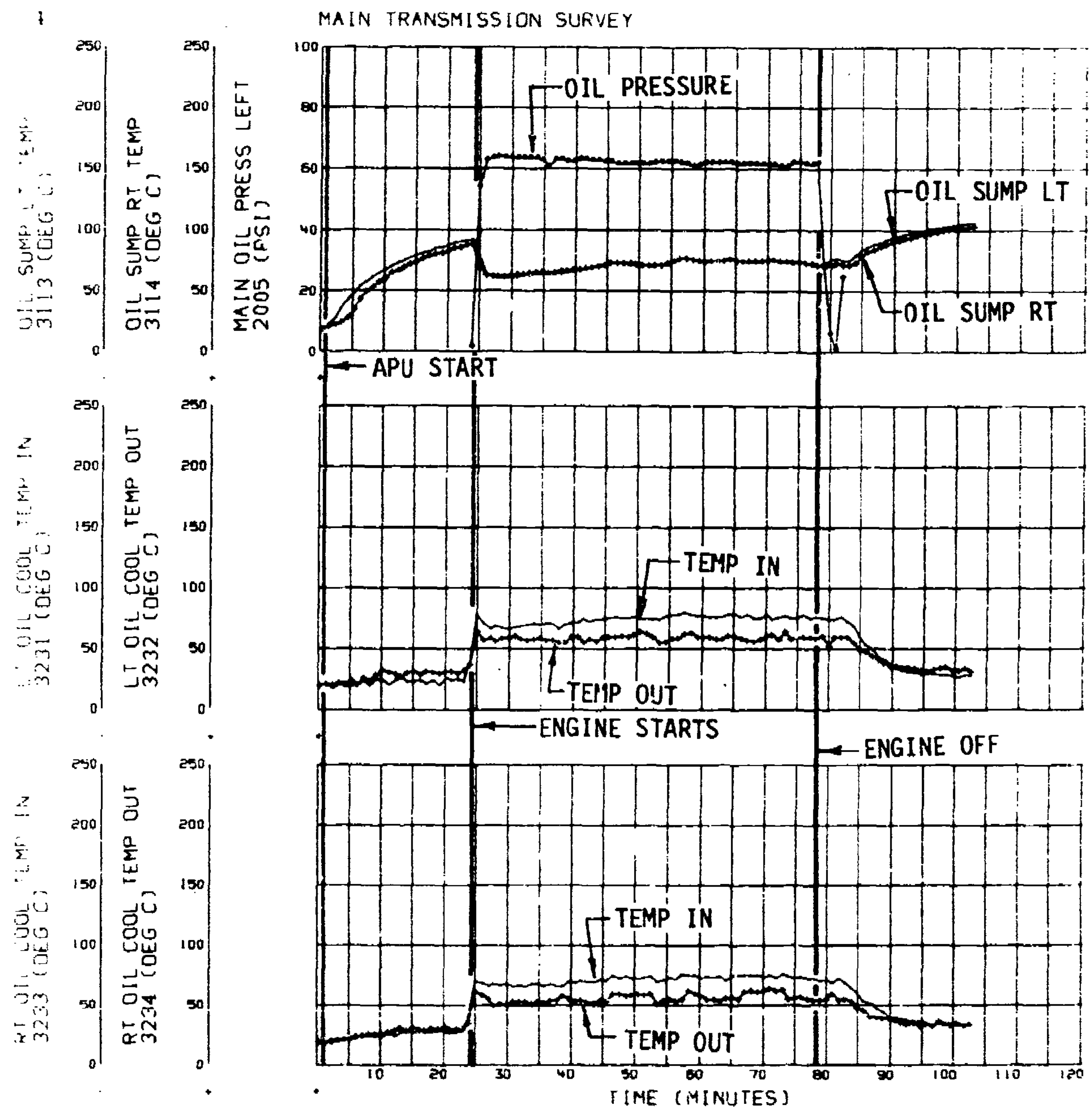


FIGURE 63
MAIN TRANSMISSION SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTE: TRANSMISSIONS SERVICED WITH MIL-L-23699C OIL

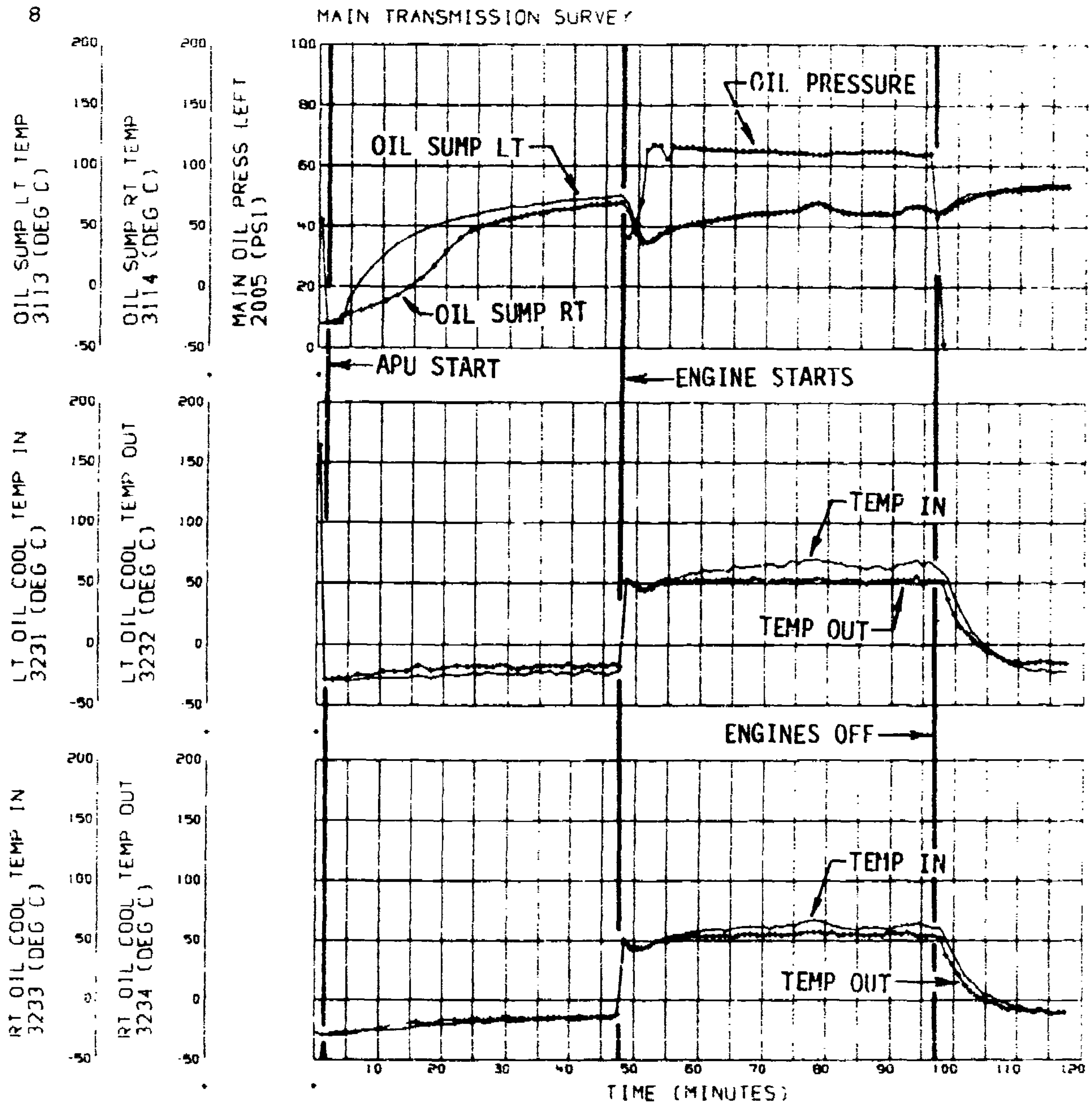


FIGURE 64

MAIN TRANSMISSION SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:

1. TRANSMISSIONS SERVICED WITH MIL-L-7808H OIL
2. MAIN TRANSMISSION RIGHT-HAND OIL PUMP BROKEN
3. MAIN TRANSMISSION LEFT-HAND PUMP OIL PRESSURE INSTRUMENTATION FAILED 60 MINUTES INTO THE RUN.

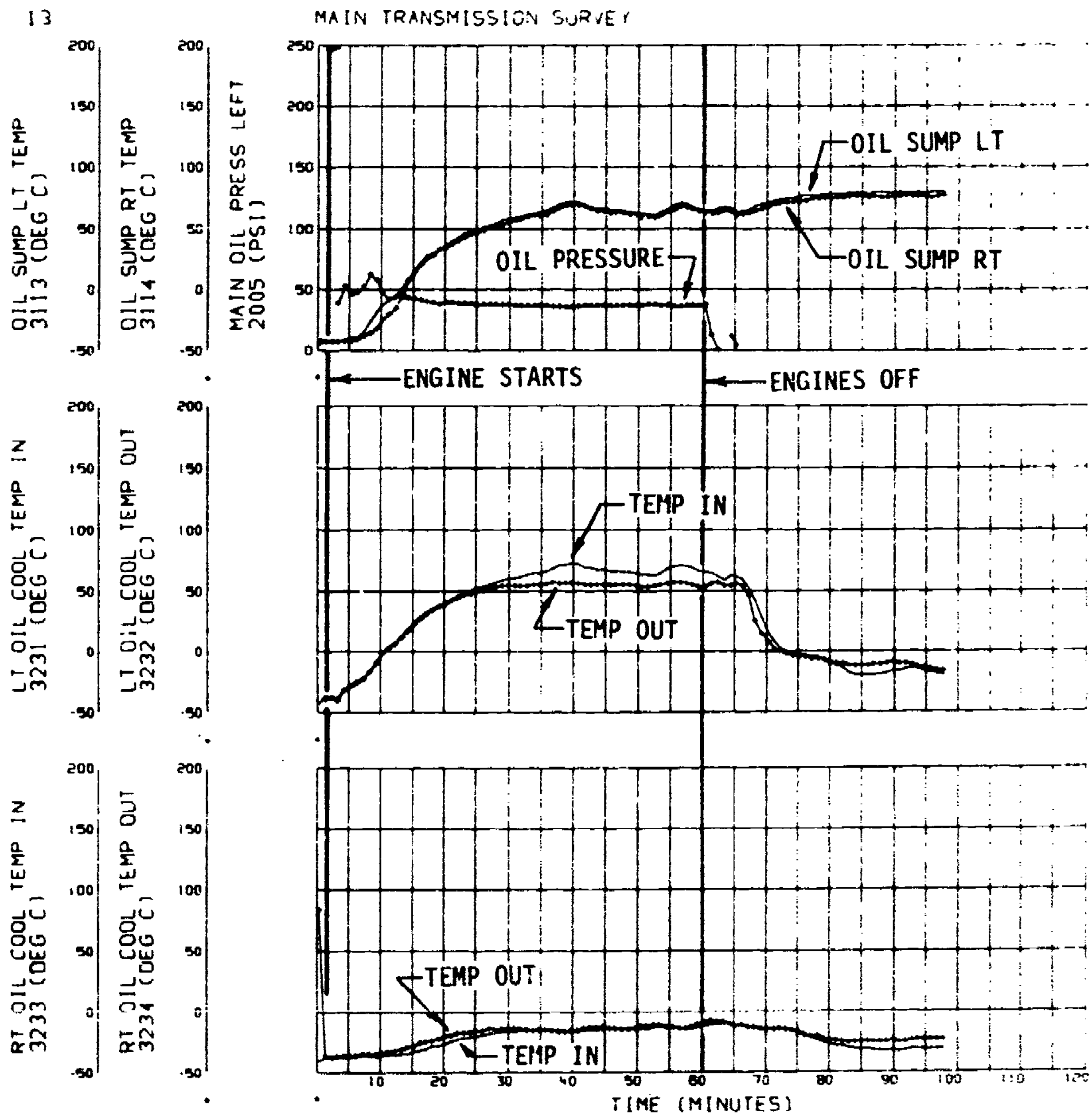


FIGURE 65

MAIN TRANSMISSION SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES: 1. TRANSMISSIONS SERVICED WITH MIL-L-7808H OIL
2. RIGHT HAND MAIN TRANSMISSION OIL PUMP FAILED

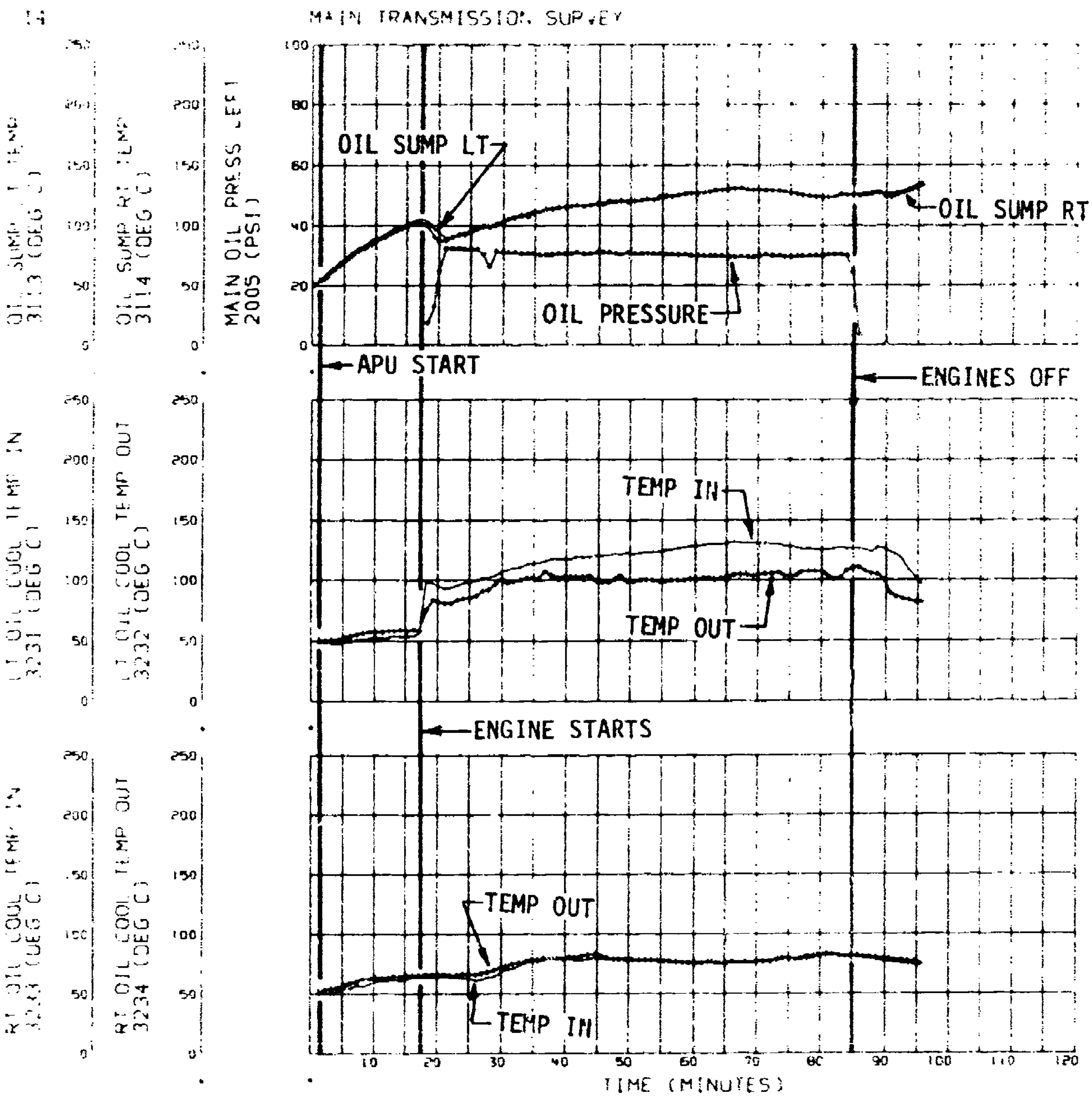


FIGURE 66
MAIN TRANSMISSION SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES: 1. TRANSMISSION SERVICED WITH MIL-L-7808H OIL

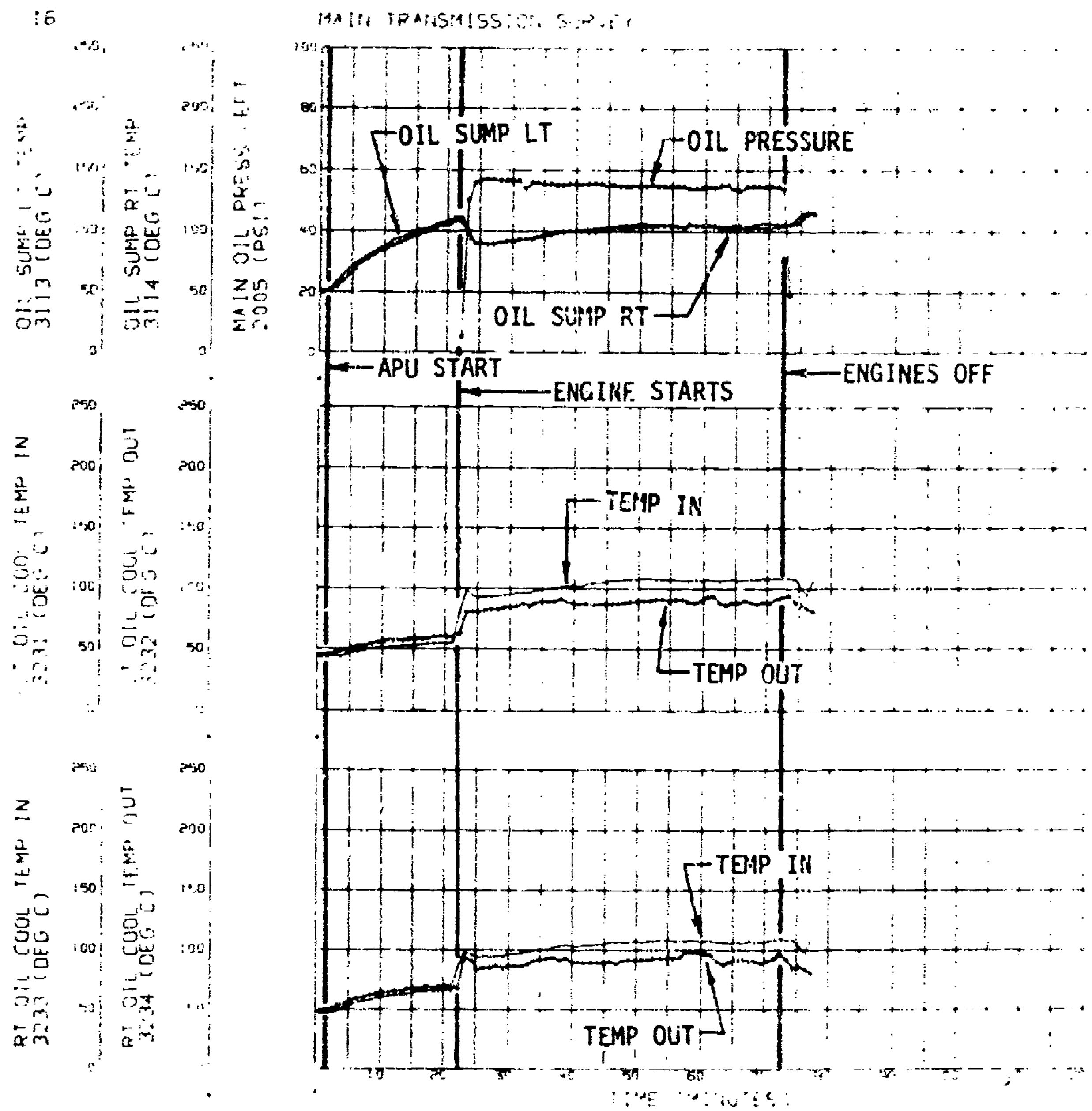


FIGURE 67
TRANSMISSIONS SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

NOTE: TRANSMISSIONS SERVICED WITH MIL-L-23699C OIL

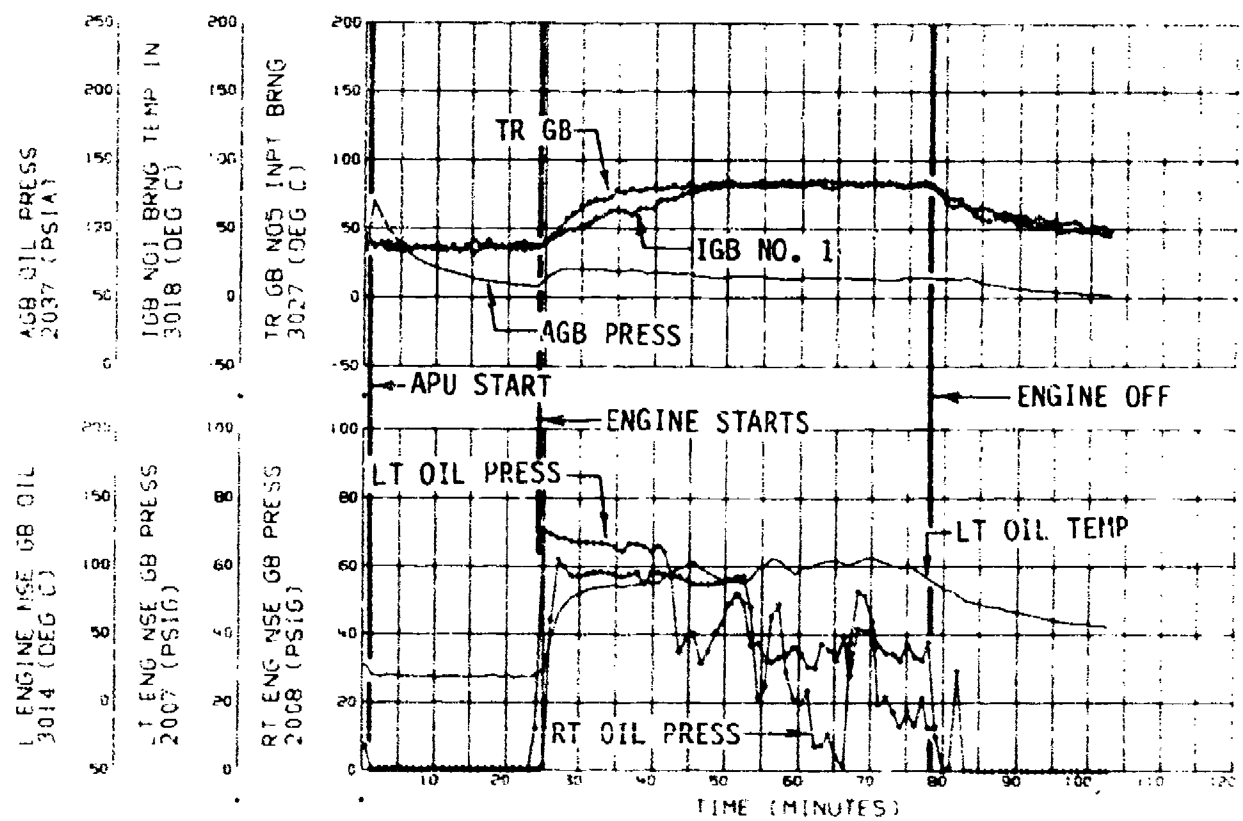


FIGURE 68
TRANSMISSION SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

NOTES:
1. TRANSMISSIONS SERVICED WITH MIL-L-23699C OIL
2. LEFT ENGINE NOSE GEARBOX OIL TEMPERATURE INSTRUMENTATION FAILED

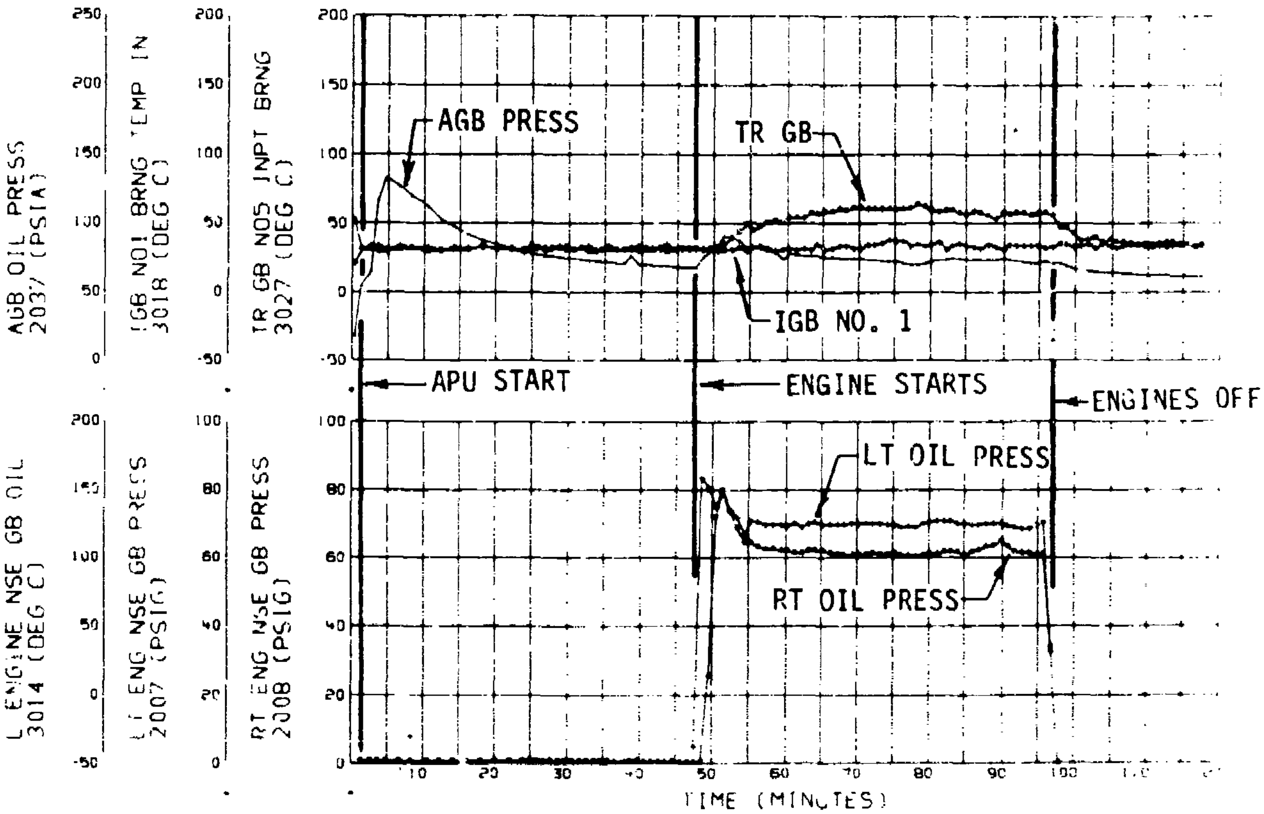


FIGURE 69

TRANSMISSIONS SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTES:
1. TRANSMISSIONS SERVICED WITH MIL-L-7808H OIL
2. LEFT ENGINE NOSE GEARBOX OIL TEMPERATURE INSTRUMENTATION FAILED

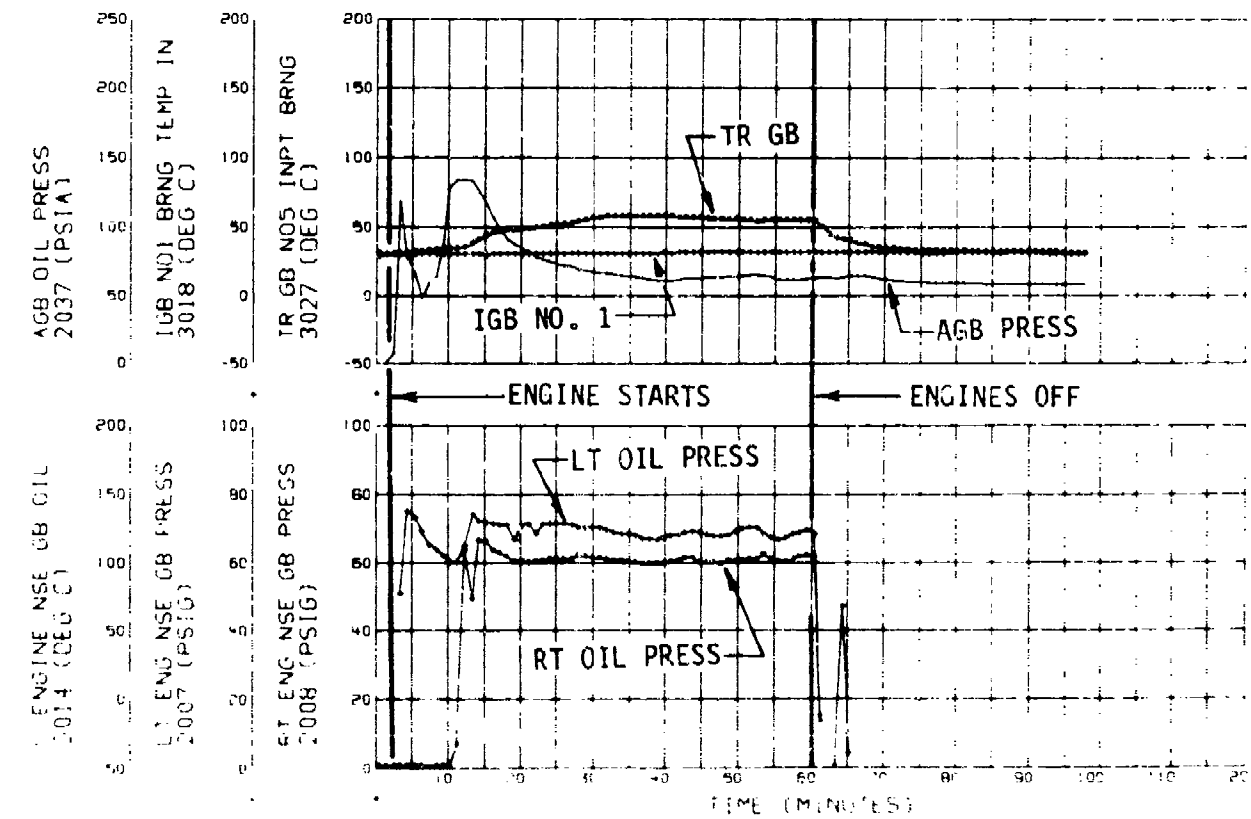


FIGURE 70

TRANSMISSIONS SURVEY

YAH-;4 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

NOTES:
1. TRANSMISSIONS SERVICED WITH MIL-L-7808H OIL
2. LEFT ENGINE NOSE GEARBOX OIL TEMPERATURE INSTRUMENTATION FAILED

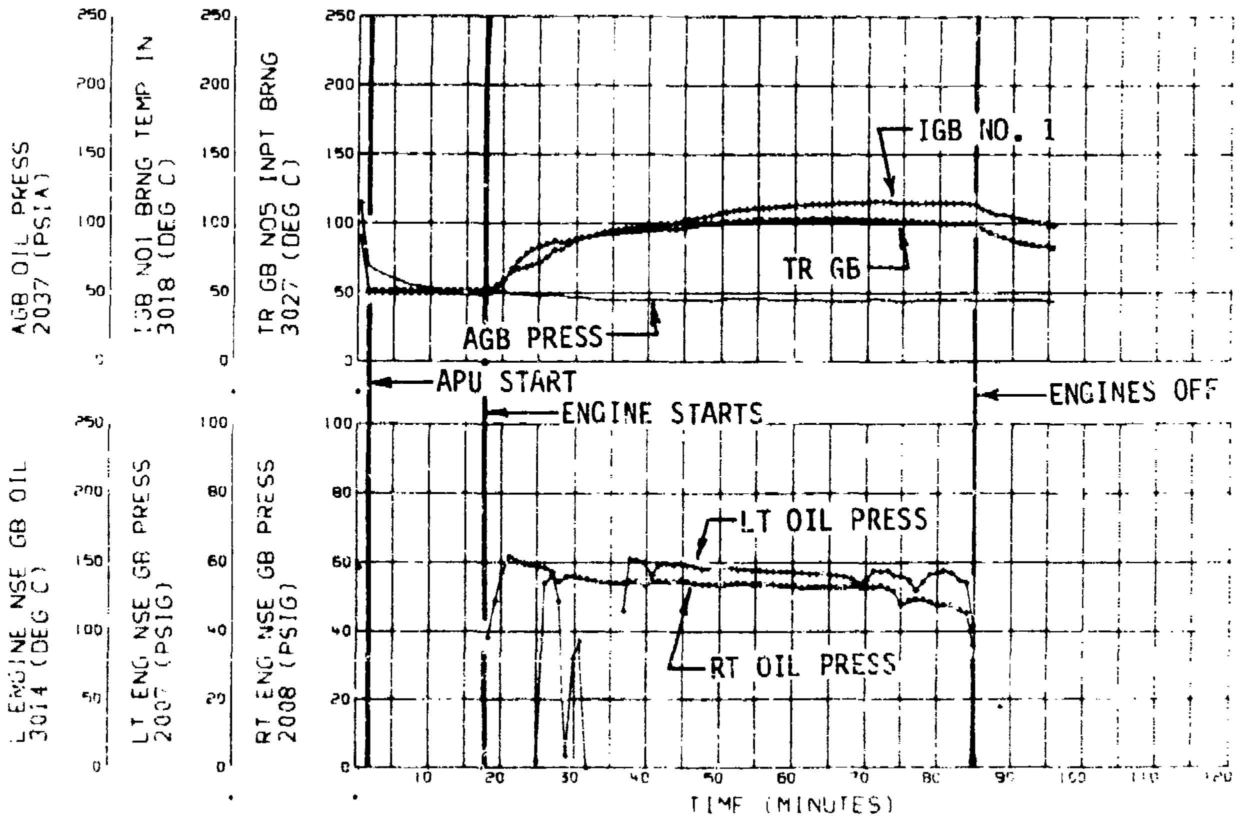


FIGURE 71
ANTI/DE-ICE SYSTEMS SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE 70°F

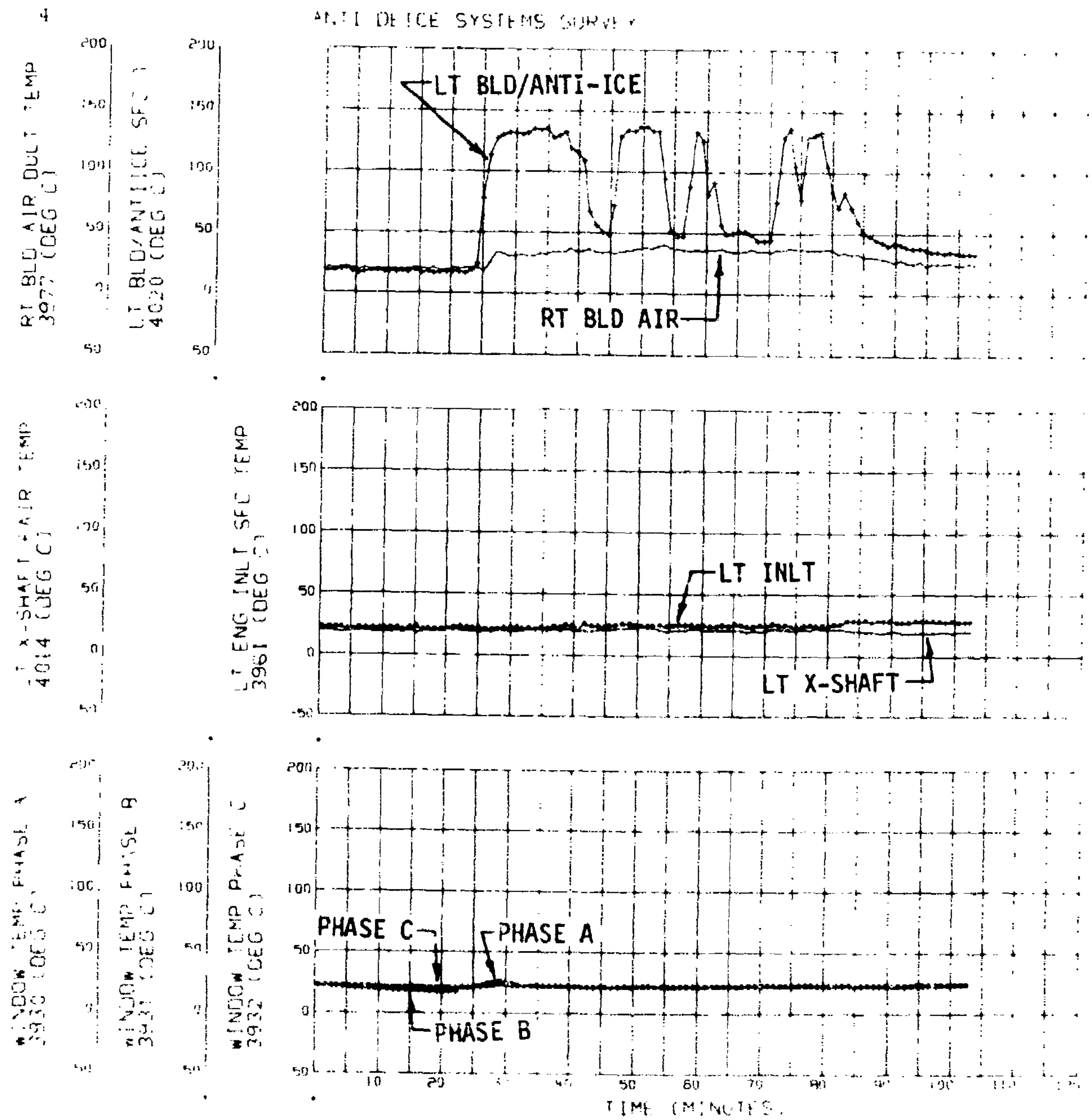


FIGURE 72
ANTI/DE-ICE SYSTEMS SURVEY
YAH-64 USA S/N 74-22249
CLIMATIC LABORATORY TEMPERATURE -25°F

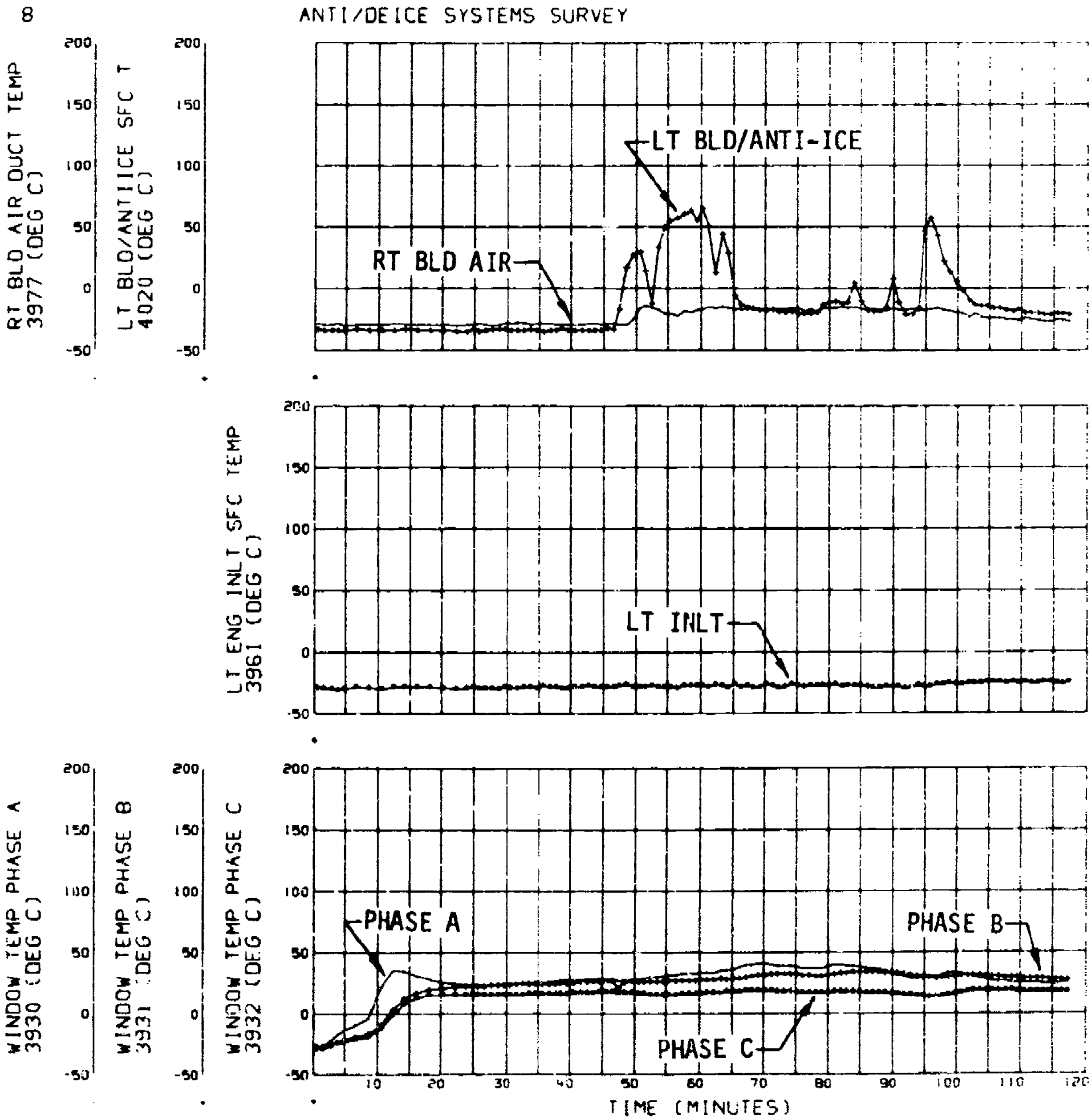


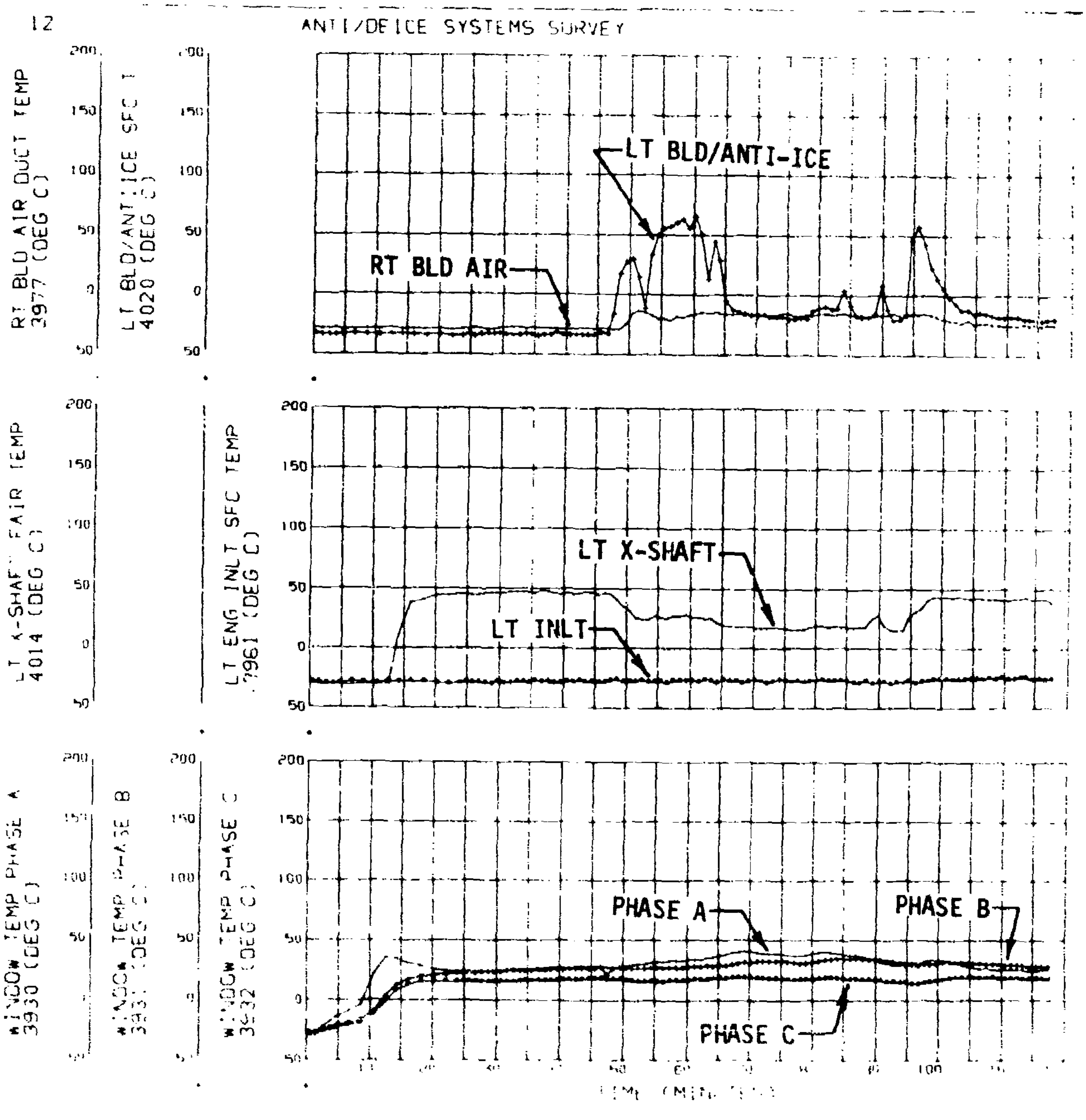
FIGURE 73

ANTI/DE-ICE SYSTEMS SURVEY

YAH-64 USA S/N 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

NOTE: LEFT ENGINE CROSS-SHAFT FAIRING INSTRUMENTATION FAILED



APPENDIX F. SERVICING RECORD

Tables 1 through 10 present fluid level and servicing information for the hydraulic systems, the engines, and transmissions.

TABLE 1

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

RUN NO. 3

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	2600	2600	
ACCUMULATOR NITROGEN PRESS	N/A	1600	N/A	
UTILITY RESERVOIR	FULLY EXTENDED	HALF EXTENDED	HALF EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	FULLY EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	MID GLASS	
MAIN #2	MID GLASS	MID GLASS	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	1/8 INCH LOW	
#2 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	1/8 INCH LOW	

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	MID GLASS	

TABLE 2

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

RUN NO. 4

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	2500	2600	
ACCUMULATOR NITROGEN PRESS	N/A	1500	N/A	
UTILITY RESERVOIR	FULLY EXTENDED	1/2 EXTENDED	1/3 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	1 IN RED EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	1/16 INCH LOW	MID GLASS	
MAIN #2	MID GLASS	1/16 INCH LOW	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	1/16 INCH LOW		5 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	1/16 INCH LOW	1/8 INCH LOW	

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	1/16 INCH LOW	1/4 INCH LOW	

TABLE 3

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE 70°F

RUN NO. 5

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	2500	2400	
ACCUMULATOR NITROGEN PRESS	N/A	1500	N/A	
UTILITY RESERVOIR	FULLY EXTENDED	2/3 EXTENDED	2/3 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	FULLY EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	MID GLASS	
MAIN #2	MID GLASS	MID GLASS	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	6 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	8 OZ

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	1/4 INCH HIGH	1/4 INCH HIGH	

TABLE 4

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

RUN NO. 6

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	2000	N/A	
ACCUMULATOR NITROGEN PRESS	N/A	N/A	N/A	TO 1350
UTILITY RESERVOIR	FULLY EXTENDED	2/3 EXTENDED	1/2 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	FULLY EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	1/4 INCH LOW	MID GLASS	
MAIN #2	MID GLASS	1/4 INCH LOW	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	1/8 INCH LOW	N/A	61 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	1/8 INCH GLASS	N/A	8 OZ

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	MID GLASS	

TABLE 5

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

RUN NO. 8

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	2800	2600	
ACCUMULATOR NITROGEN PRESS	N/A	N/A	N/A	
UTILITY RESERVOIR	FULLY EXTENDED	1/4 EXTENDED	1/3 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	FULLY EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	1/8 INCH LOW	MID GLASS	
MAIN #2	MID GLASS	1/8 INCH LOW	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	12 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	6 OZ

#1 ENGINE OIL	MID GLASS	FULL GLASS	——	1 QUART
#2 ENGINE OIL	FULL GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	MID GLASS	

TABLE 6

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

RUN NO. 12

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	N/A	N/A	
ACCUMULATOR NITROGEN PRESS	N/A	1450	1100	
UTILITY RESERVOIR	FULLY EXTENDED	RETRACTED	1/2 EXTENDED	FROM CART
PRIMARY RESERVOIR	FULLY EXTENDED	2/3 EXTENDED	2/3 EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	FULL GLASS	
MAIN #2	MID GLASS	MID GLASS	FULL GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	MID GLASS	
#2 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	14 OZ

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	1 QUART
#2 ENGINE OIL	FULL GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	2/3 GLASS	FULL GLASS	

TABLE 7

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE -50°F

RUN NO. 13

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	N/A	N/A	
ACCUMULATOR NITROGEN PRESS	N/A	1100	N/A	TO 1800
UTILITY RESERVOIR	FULLY EXTENDED	1/2 EXTENDED	FULLY EXTENDED	FROM MULE
PRIMARY RESERVOIR	FULLY EXTENDED	2/3 EXTENDED	2/3 EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	MID GLASS	
MAIN #2	MID GLASS	1/16 INCH LOW	1/8 INCH HIGH	
#1 ENGINE NOSE GEARBOX	MID GLASS	1/8 INCH LOW	1/8 INCH HIGH	
#2 ENGINE NOSE GEARBOX	MID GLASS	1/8 INCH LOW	1/8 INCH HIGH	

#1 ENGINE OIL	MID GLASS	FULL GLASS	N/A	-2 QUARTS
#2 ENGINE OIL	FULL GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	2/3 GLASS	

TABLE 8

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

RUN NO. 14

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	N/A	N/A	
ACCUMULATOR NITROGEN PRESS	N/A	1750	1800	TO 1750
UTILITY RESERVOIR	FULLY EXTENDED	RETRACTED	FULLY EXTENDED	FROM MULE
PRIMARY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	3/4 EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	FULL GLASS	
MAIN #2	MID GLASS	1/8 INCH HIGH	FULL GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	1/8 INCH HIGH	N/A	
#2 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	FULL GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	MID GLASS	

TABLE 9

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE 125°F

RUN NO. 16

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	3000	2850	
ACCUMULATOR NITROGEN PRESS	N/A	1825	N/A	TO 1825
UTILITY RESERVOIR	FULLY EXTENDED	FULLY EXTENDED	2/3 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	3/4 EXTENDED	3/4 EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	MID GLASS	BUBBLE AT TOP	
MAIN #2	MID GLASS	MID GLASS	BUBBLE AT TOP	
#1 ENGINE NOSE GEARBOX	MID GLASS	MID GLASS	N/A	6 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	FULL GLASS	N/A	32 OZ

#1 ENGINE OIL	MID GLASS	FULL GLASS	FULL GLASS	
#2 ENGINE OIL	FULL GLASS	FULL GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	2/3 GLASS	

TABLE 10

SERVICING RECORD

YAH-64 USA 74-22249

CLIMATIC LABORATORY TEMPERATURE -25°F

RUN NO. 17

HYDRAULICS	NORMAL	PRERUN	POSTRUN	SERVICING
ACCUMULATOR PRESS	3000	3000	2750	TO 3000
ACCUMULATOR NITROGEN PRESS	N/A	1200	N/A	
UTILITY RESERVOIR	FULLY EXTENDED	2/3 EXTENDED	1/2 EXTENDED	
PRIMARY RESERVOIR	FULLY EXTENDED	1/2 EXTENDED	2/3 EXTENDED	

TRANSMISSIONS				
MAIN #1	MID GLASS	1/8 INCH LOW	MID GLASS	
MAIN #2	MID GLASS	1/8 INCH LOW	MID GLASS	
#1 ENGINE NOSE GEARBOX	MID GLASS	BOTTOM OF GLASS	BELOW GLASS	6 OZ
#2 ENGINE NOSE GEARBOX	MID GLASS	BOTTOM OF GLASS	BELOW GLASS	4 OZ AND 12 OZ

#1 ENGINE OIL	MID GLASS	BUBBLE AT TOP	FULL GLASS	
#2 ENGINE OIL	MID GLASS	BOTTOM OF GLASS	FULL GLASS	
APU OIL	MID GLASS	MID GLASS	INCH HIGH	

APPENDIX G. EQUIPMENT PERFORMANCE REPORTS

NUMBER	TITLE	Test Temperatue (°F)
80-07-1	Engine Nose Gearbox	+70
80-07-2	#2 Eng Fuel Filter Housing	+70
80-07-3	Prim Hyd Sys Press Trans	+70
80-07-4	Util Hyd Accumulator	+70
80-07-5	Util Hyd - Manifold Solenoid	-25
80-07-6	Fuel Pump	-25
80-07-7	Eng NR 2	-25
80-07-8	Press Air System	+70
80-07-9	NiCad Battery	-25
80-07-10	NiCad Battery Instl	-25
80-07-11	Power Quadrant	-25
80-07-12	Fan, Van Axial, Aft	-25
80-07-13	Pylon & Rack Assy	-25
80-07-14	Manifold, Hyd Sys	-25
80-07-15	Accumulator Assy	-50
80-07-16	Pump Assym Hyd	-50
80-07-17	Manifold, Hyd Assy	-50
80-07-18	Hyd Hose, Press, Primary	-50
80-07-19	APU	-50
80-07-20	CPG Windshield	-50
80-07-21	Hose, Hydraulic	-50
80-07-22	Hydro Mech Unit	-50
80-07-23	Manifold, Hyd	-50
80-07-24	Clock (CPM)	-50
80-07-25	Main Rotor Trans	-50/ +125
80-07-26	Mechanical Flt Controls	-50
80-07-27	Eng Nose GB Fairings	-50
80-07-28	APU	-50
80-07-29	Accumulator Assy	-50
80-07-30	Trans Rectifier #2	+125
80-07-31	Press Gage - Util Hyd Accum	ALL
80-07-32	DASE	-25
80-07-33	Manifold, Util Hyd	+125
80-07-34	MLG Brake	+125
80-07-35	Control Box, Stabailator	+125
80-07-36	Eng NR 1	+125
80-07-37	Eng NR 1	+125
80-07-38	SDC Check Valve	+125
80-07-39	Anti-ice Valve	+70

NUMBER	TITLE	Test Temperatue (°F)
80-07-40	Propulsion Sys Panel	+125
80-07-41	Accumulator, Util Hyd	+75
80-07-42	Eng Nose Gearboxes	ALL
80-07-43	Service Criteria	ALL
80-07-44	Main Rotor Trans	+20
80-07-45	APU	-25
80-07-46	Util Hyd override Solenoid	-25
80-07-47	Hose Assy	-25
80-07-48	Flame Detector	-25
80-07-49	Hyd Press Indicator	-25
80-C7-50	Battery Charger Assy	-25

APPENDIX H.
MISSION EQUIPMENT TEST RESULTS

TECOM PROJECT NO. 4-AI-100-AAH-015

TEST SPONSOR: PMO-AAH

FINAL TEST REPORT

CLIMATIC LABORATORY SURVEY

OF THE

YAH-64 ADVANCED ATTACK HELICOPTER

MISSION EQUIPMENT

BY

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FEBRUARY 1982

REVISED

MARCH 1982

UNITED STATES ARMY AVIATION DEVELOPMENT TEST ACTIVITY

FORT RUCKER, ALABAMA 36362

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DEPARTMENT OF THE ARMY
US ARMY AVIATION DEVELOPMENT TEST ACTIVITY
FORT RUCKER, ALABAMA 36362

STEBG-CO-AA

SUBJECT: Final Report, Climatic Laboratory Survey of the YAH-64 Advanced Attack Helicopter Mission Equipment, TECOM Project Number 4-AI-100-AAH-015

Commander
US Army Test and Evaluation Command
ATTN: DRSTE-CT-A
Aberdeen Proving Ground, MD 21005

1. REFERENCES

1.1 Letter, DRSTE-CT-A, Headquarters, US Army Test and Evaluation Command, 30 July 1980, subject: Customer Support Directive for EDT-G, YAH-64 Climatic Laboratory Survey, TECOM Project No. 4-AI-100-AAH-015.

1.2 Letter, DRSTE-CT-A, Headquarters, US Army Test and Evaluation Command, 10 September 1981, subject: Change 1, Customer Support Directive for EDT-G, YAH-64 Climatic Laboratory Survey, TECOM Project No. 4-AI-100-AAH-015.

1.3 Letter, DRSTE-CT-A, Headquarters, US Army Test and Evaluation Command, 8 October 1981, subject: Support Directive for EDT-G, YAH-64 Climatic Laboratory Survey, TECOM Project No. 4-AI-100-AAH-015.

1.4 Test Plan, US Army Aviation Engineering Flight Activity, "Climatic Laboratory Survey Hughes YAH-64 Helicopter," August 1981.

1.5 Final Test Report, US Army Aviation Development Test Activity, "Engineering Design Test-Government (EDT-G) No. 5 of the Advanced Attack Helicopter (AAH) (YAH-64)," May 1981.

1.6 System Specification, Advanced Attack Helicopter, YAH-64 Phase 2, Vol. 1, Book 1, AMC-SS-AAH-H10000A, Hughes Helicopters, Revised 23 Nov 76.

1.7 Technical Manual (TM) 55-1520-238-10, Operator's Manual for Army YAH-64 Helicopter, 1 May 1981.

2. BACKGROUND

The US Army Aviation Development Test Activity (USAAVNDTA) was tasked by the US Army Test and Evaluation Command (TECOM) to support and participate in the YAH-64 Climatic Laboratory Survey (ref 1.1, 1.2, and 1.3) which was jointly conducted by the US Army Aviation Engineering Flight Activity (AEFA) and the

USAAVNDTA. An AEFA test plan was published in August 1981 (ref 1.4). The mission equipment test performed by USAAVNDTA was incorporated as a part of the AEFA test plan.

3. TEST OBJECTIVES

The objective of the Climatic Laboratory Survey was to verify that the YAH-64 helicopter mission equipment could function satisfactorily throughout a selected range of climatic extremes.

4. DESCRIPTION

The test aircraft was a YAH-64 Advanced Attack Helicopter, Army serial number (ASN) 74-2249 (AVO 3) with a competitive development Target Acquisition Designation Sight/Pilot Night Vision Sensor (TADS/PNVS) TADS SN CD 7 and PNVS SN 3. The aircraft was equipped with four wing store pylons, 30mm chain gun, and one training HELLFIRE missile. TADS/PNVS anti-icing was operational. Only the inboard wing stores stations were used to load three HELLFIRE dummy missiles per station. Rocket pods were not installed on the outboard stations. A basic description of the YAH-64 mission equipment and systems is presented in reference 1.5.

5. SCOPE

The test was conducted at Eglin Air Force Base, Florida, in the McKinley Climatic Laboratory from 3 November 1981 through 15 December 1981. A total of 14.4 hours of aircraft operational time was conducted. System performance was evaluated against the requirements of Hughes Helicopters, System Specification (Phase 2), AMC-55-AAH-H10000A, revised November 1976 (ref 1.6), and Technical Manual (TM) 55-1520-238-10, Operator's Manual for Army YAH-64 Helicopter, 1 May 1981 (ref 1.7). Instrumentation, maintenance, and support were provided by Hughes Helicopters and Martin Marietta.

6. TEST METHODOLOGY

6.1 The YAH-64 mission equipment was evaluated at the designated temperatures of +70°F (+21.1°C) (baseline, -25°F (-31.7°C), -50°F (-45.6°C), and +125°F (+51.7°C). A test matrix is presented in Incl 3, table 3-1. Additional data were derived between designated test temperatures in the performance of maintenance or check runs (+10°F (-12.2°C), +16°F (-8.8°C), and +36°F (+2.2°C)). Efforts were made to insure that the aircraft and mission systems were returned to a baseline condition prior to each change in designated test temperature. Malfunctioning characteristics which occurred at +70°F (+21.1°C) and those that were consistently noted at various other test temperatures were considered to be random failures and not necessarily temperature related.

6.2 The test crew included an experimental test pilot from AEFA, a copilot/-gunner (CPG) from USAAVNDTA, and a CPG from the Development Test and Training Detachment (DTTD). The tests were performed using the TM 55-1520-238-10 check-list as a test card (see AEFA portion of report) at each temperature for the mission equipment which included TADS/PNVS, 30mm chain gun, HELLFIRE missile system, and associated systems and components. Dummy 30mm ammo was cycled through the 30mm gun, and a training missile was used to simulate firing. Video and symbology were recorded by on-board video tape. Data were acquired with the CPG in control of TADS and gun, the pilot in control of the PNVS and gun. TADS/PNVS turn-on temperatures, TADS/PNVS anti-icing parameters, and fire control system characteristics were recorded through limited instrumentation presentation in an instrumentation and control booth. Cockpit voice communication, TADS/PNVS, and Integrated Helmet and Display Sight Subsystem (IHADSS) video/-symbology were monitored in real time by support personnel in the control booth.

7. RESULTS AND DISCUSSION

7.1 General

Many of the components and systems were not the latest configurations which precluded an adequate climatic evaluation for a system which is about to enter production. It appears that a significant number of the problems encountered can be directly related to the inadequacy of the Environmental Control Unit (ENCU) and system for both cold and hot temperatures. Comments relating to modification and qualification of these systems and components are included in the Equipment Performance Report (EPR) Summary presented in Incl 2. This summary also provides information to indicate if the malfunction was temperature related. Additional detailed test data is presented in Incl 3.

7.2 Target Acquisition and Designation Sight (TADS)

7.2.1 TADS Configuration. The TADS system tested was not of the "P" or production system configuration. A Competition Development TADS system, SN 007, was prepared for the Climatic Laboratory Survey. The test item was delivered with several system unique characteristics and inadequacies which were noted prior to test initiation or during the conduct of the survey. These characteristics are presented in Incl 3, table 3-2.

7.2.2 TADS Test Results

7.2.2.1 Baseline Random Failures/Characteristics. Two characteristics were noted at +70°F (+21.1°C): the TADS would not couple with the IHADSS in the HMD/TADS position (EPR KF-7) and control of the TADS was lost when the PNVS was switched to NVS by the pilot (EPR KF-8). Neither item could be duplicated. A summary of the TADS air inlet temperature data for the various test temperatures is presented in Incl 3, table 3-3. At +70°F (+21.1°C), the ENCU was providing an average temperature between data runs of +22.2°C to the TADS inlet.

7.2.2.2 Maintenance Check, +16°F (-8.8°C). At this temperature the first failure of the TADS occurred during slewing checks. The TADS stuck at about 45 degrees left and up. All displays and symbology were lost, except for a bright line midway in the Heads Down Display (HDD). The PNVS would not return to stow. It was found that the 28 VDC circuit breaker had tripped in the TADS power supply located in the right FAB (Incl 3, fig 3-5). This malfunction continued to occur at -25°F (-31.7°C) and -50°F (-45.6°C). The malfunction appears to be temperature related in that it never occurred at +70°F (+21.1°C) and +125°F (+51.7°C). This characteristic is considered a shortcoming. The circuit breaker was replaced after the survey, but was reported to continue tripping, indicating a failure elsewhere within the system.

7.2.2.3 Characteristics, -25°F (-31.7°C). Several problems occurred at this temperature as shown in table 1 with the appropriate characteristics marked as shortcomings. Malfunctions are referenced to the EPR's summarized in Incl 2, table 2-1, which also indicates if the malfunction was temperature related. As shown in Incl 3, table 3-3, a steady state air temperature of approximately +25°C was provided to the TADS inlet by the ENCU. To achieve this temperature required 30 to 35 minutes and was then maintained for approximately 65 minutes before gradually increasing to +35°C, at which time the test was terminated.

Table 1. TADS -25°F (-31°C) Characteristics

	Item	Shortcoming
1.	TADS failed (28 VDC circuit breaker tripped). See EPR No. KF 36-S-1	Yes
2.	Heads up display compression of video. (EPR No. KF-18)	Yes
3.	DTV camera inoperative (EPR No. KF-64-S1).	Yes
4.	Intermittent laser (EPR No. KF-22).	Yes
5.	CPG unable to monitor TADS with pilot in command of TADS (EPR No. KF-17).	No
6.	FLIR boresight retention could not be checked (EPR No. KF-21,, 21-S1, 24).	No
7.	The TADS video would not appear in the Helmet Mounted Display (HMD) except when HMD/TADS was selected. Any other sight select position resulted in a blank HMD.	No
8.	Pilot did not have any HMD symbology.	No

Note: Items 7 and 8 did not have EPR's written against them. These items may have been produced by significant IHADSS problems which existed when they were noted.

7.2.2.4 Characteristics, -50°F (-45.6°C)

a. The TADS Environmental Control System (ECS) Control Box was modified to accommodate TADS operation at temperatures below -25°F (-31.7°C). This modification consisted of the TADS internal ECS Control Box rewiring and the addition of a two position switch external to the system to allow the TADS fan to operate prior to system "turn on" to provide heated air to the system. Special operating instructions were also provided which required a TADS inlet temperature equal to +40°F (+4.4°C) for 28 minutes prior to positioning the CPG sight select switch to standby and then turning the TADS power switch on. A 15 minute wait was then required before operation. If the TADS inlet temperature failed to obtain +40°F (+4.4°C), the ECS had to operate for the minimum times shown in table 2.

Table 2. TADS ECS Operating Requirements Below -25°F (-31°C)

TADS Inlet Temperature	Minimum ECS Operating Time
0°F (-17.8°C)	60 minutes
10°F (-12.1°C)	48 minutes
20°F (-6.7°C)	38 minutes
30°F (-1.1°C)	35 minutes

b. TADS air inlet temperature data is summarized in Incl 3, table 3-3, and also presented in Incl 3, figure 3-3. Two -50°F (-45.6°C) test runs were available for TADS operation: (1) During the first run, the minimum ECS run time was started at a TADS inlet temperature of 0°F (-17.7°C) which allows a minimum run time of 60 minutes prior to turning the TADS on. As the aircraft ENCU continued to provide warmer air, the time lapse precluded using any other minimum run time. After 42 minutes into the test run, the TADS inlet temperature was -4°C. When 60 minutes had been reached, the 40°F temperature had not been provided by the ENCU, the symbol generator had not provided symbology, the aircraft portion of the test had been concluded; therefore, the TADS was not turned on and the test was terminated. (2) The second run was conducted with the fire control computer and symbol generator preheated. After the minimum time had been reached and the TADS was switched out of standby the TADS 28 VDC circuit breaker tripped and the system was turned off and the test was terminated.

c. The significant TADS system problems are presented in table 3.

Table 3. TADS -50°F (-45.6°C) Characteristics

Item	Shortcoming
1. TADS system tripped the TADS power supply 28 VDC circuit breaker (EPR No. KF-36).	Yes
2. Gray scale was not present on any displays (EPR No. KF-40).	No
3. Heads Up Display (HUD) did not have symbology (EPR No. KF-41).	No
4. Heads Down Display (HDD) symbol set reticle missing (EPR No. KF-42).	No

7.2.2.5 Characteristics, +125°F (+51.7°C). The following system malfunction/-characteristics were noted. Analysis of these characteristics are presented under the appropriate EPR in incl 2, table 2-1. Based on this survey, the YAH-64 TADS system can not adequately function at +125°F (+51.7°C) with the present environmental conditioning available. Inadequate cooling air is provided to the TADS, electronic boxes in the forward avionics bays (FABS), and the cockpit and is considered a deficiency. FABS inlet air temperatures are summarized in Incl 3, table 3-4, and also presented in time history format in Incl 3, figures 3-1 through 3-4. Heat sensitive tabs located in the FABS indicated that the EU-1 box reached +160°F (+71.1°C) and the remote HELLFIRE electronics (RHE) reached +140°F (+60°C). Contractor personnel stated that most of the problems at this temperature came from the time generator card in the EU-2 box (incl 3, fig 3-5).

a. The TADS system failed after 56.5 minutes (EPR No. KF-61).

(1) The TADS caution light illuminated.

(2) The CPG's HMD went to gray scale.

(3) The HUD went blank except for a horizontal white line.

(4) All control of TADS was lost.

(5) Circuit breakers were in.

b. The HDD on the ORT was inoperative (EPR No. KF-59).

c. The HUD on ORT had compressed video and symbology toward the center of the display with a vertical line at the display center.

d. Deterioration of the DTV camera was observed (EPR No. KF-64).

e. Pilot lost control of the PNVS in elevation. The problem was evaluated by contractor personnel and found to be derived from the thermal protection switch on the PNVS elevation motor indicating overheating.

f. PNVS video and symbology was very scrambled when the PC-16 (automatic contrast control) switch was operated.

g. The CPG could not command the PNVS.

After "cool down" of the hangar, the system was checked at a temperature of approximately +36°F (+2.2°C) and found to be operable. During the next run at -25°F (-31.7°C) the DTV camera was totally inoperative.

7.2.2.6 TADS Boresight Characteristics

a. General. Overall boresight characteristics including boresight retention checks were unsatisfactory except for portions of the DTV system. This was primarily due to the use of outmoded competition development (CD) systems for the Climatic Laboratory Survey. A summary of system onboard boresight checks is presented in incl 3, table 3-5.

b. DVO. DVO boresight characteristics were difficult to evaluate in the climatic hangar due to low light level conditions. With the competition development (CD) TADS there was no DVO reticle lighting which made it more difficult to define where the TADS was pointed (orientation). "Out front" boresight checks had to be made capturing one of the hangar overhead lights. The DVO boresight could not be accomplished at -25°F (-31.7°C) and -50°F (-45.6°C) test points due to the inability of the DVO boresight system to "spiral". This characteristic was considered to be a shortcoming. The CPG was able to get the DVO spiral to "break loose" at +16°F (-8.8°C).

c. FLIR. The FLIR boresight in most cases had to be accomplished using nonstandard procedures which is a unique characteristic of the early CD systems. The boresight cue did not appear and the tracking gates would not capture the cue. The alternate boresight routine had to be performed by utilizing manual search and acquiring of the cue which was time consuming and only gave approximate centering with the image automatic tracking (IAT) gates. The system would intermittently lose the boresight vector which precluded any check of boresight retention.

d. DTV. DTV boresight and retention procedures were qualitatively evaluated as being satisfactory. Problems were experienced with the laser in that it was intermittent as a function of decrease in temperature. This characteristic was noted at -25°F (-31.7°C) and is considered to be a shortcoming. On the initial laser trigger pull at this temperature, the laser did not appear

to work but would eventually start pulsing with intermittent pulses. Additional tests at cold temperatures should be conducted to determine if the laser pulse code frequency is actually changing with temperature which could preclude missile operation.

7.3 Pilot Night Vision Sensor (PNVS)

7.3.1 PNVS Configuration. The PNVS system tested was a Competition Development (CD) system, serial number 003. Although this is a CD system, no significant changes are known to be planned for production. A characteristic unique to the CD TADS/PNVS system was that when the pilot selects PNVS, the TADS TV video would become unuseable due to a previously defined phase-lock loop sync phenomenon. This prevented the TADS from being operated simultaneously with the PNVS.

7.3.2 PNVS Test Results

7.3.2.1 The PNVS operated satisfactorily at the baseline (+70°F (+21.1°C)) temperature. The TADS power supply 28 VDC circuit breaker tripping problem, which became evident at +16°F (-8.8°C) and colder, also incapacitated the PNVS. Primarily, the only PNVS independent problems were at +125°F (+51.7°C) whereas the PNVS elevation control was lost and operation of the PC-16 switch produced a scrambled PNVS display. The PC-16 function provides an automatic contrast control capability for the PNVS video.

7.3.2.2 The PNVS was prohibited from operation below -25°F (-31.7°C) and therefore could not be operated at the -50°F (-45.6°C) test temperature.

7.4 Fire Control System

7.4.1 Fire Control Computer (FCC)

7.4.1.1 The FCC was evaluated for the proper accomplishment of its capability to control the multiplex system and provide fire control for the weapon systems. The unit tested was reported to not be a production configuration. Production changes are unknown by USAAVNDTA.

7.4.1.2 The FCC (incl 3, figure 3-6) was replaced three times during the conduct of the test for the malfunctions presented in table 4. Also, the last installed FCC indicated some loss of its capabilities during the later part of the Climatic Survey. An analysis of the FCC malfunctions is presented in the appropriate EPR in incl 2, table 2-1. Based on the number of FCC malfunctions and the number of FCC's required to complete the survey, the FCC as a system component is considered unreliable. This characteristic is considered to be a deficiency (incl 1, para 1.1).

Table 4. Fire Control Computer Malfunctions

1. The FCC lost all memory and tripped the BITE indicator two times at -25°F (-31.1°C). This loss of memory renders the FCC unuseable. The units were replaced.

2. At -50°F (-45.6°C) the FCC D.C. circuit breaker tripped and could not be reset due to an internal short in the FCC. The FCC was replaced.

3. At +125°F (+51.7°C) the FCC exhibited programming anomalies. The preflight Grid Zone data entered into the computer would truncate. Entries that were accepted into the computer would later truncate a digit up or down. This affected the TADS waypoint target accuracy. Also at +125°F (+51.7°C), even when the proper preflight data was being retained, the FCC directed the TADS the wrong direction when waypointing.

7.4.2 Backup Bus Controller (BBC)

7.4.2.1 The BBC was evaluated for its capability to automatically assume control of the multiplex system in case of primary BUS controller failure (FCC). The BBC was not a production configuration unit.

7.4.2.2 The BBC operated properly when switching from primary to secondary. However; due to improper software programming, the BBC could not provide any control over the weapon systems. This impacted the Climatic Survey when the FCC had been removed or malfunctioned. The BBC was replaced once during the Climatic Survey.

7.4.3 Pilot's Multiplex Remote Terminal Unit (MRTU). The pilot's MRTU failed at +70°F (+21.1°C) (EPR No. KF-4) and was considered a baseline non-temperature related random failure. The resulting loss of proper multiplex communications resulted in several mission equipment anomalies which are noted as follows:

7.4.3.1 The loss of all IHADSS video and symbology to the pilot and CPG.

7.4.3.2 The uncommanded transfer of the TADS to the pilot, with loss of control of the TADS system for both the pilot and CPG.

7.4.3.3 Other multiplex anomalies, plus a FD/LS indication of: multiplex communication no-go, lefthand FAB.

7.4.4 Copilot/Gunner's Fire Control Panel (FCP). The CPG's FCP microprocessor failed at +70°F (+21.1°C) (EPR No. KF-57). This failure resulted in the inability to control any of the armament systems. This also produced an invalid

coding of the TADS Laser Designator seen by an intermittent laser spot in the boresight mode. A review of the eight stored addresses containing different laser codes revealed improper pulse rates for the commanded addresses.

7.4.5 YAH-64 Symbol Generator (YSG). The YSG (incl 3, figure 3-5) is a major component of the fire control system in that it provides video signals. alphanumeric characters and symbology to the displays. Without this information, mission equipment pre-checks cannot be performed. Excessive YSG warm-up time at -25°F (-31.7°C) and below would preclude a normal quick reaction capability and is considered a deficiency. The YSG was usable instantaneously at +70°F (+21.1°C) and +125°F (+51.7°C) test temperatures; 3.3 minutes were required at +16°F (-8.8°C), up to 24 minutes at -25°F (-31.7°C) and preheat was required at -50°F (-45.6°C). YSG warm-up times for the aurvey are presented in Incl 3, table 3-6. The aircraft ENCU appears to be inadequate for supplying proper heated/cooled air to the electrical components located in the FABS and is considered to be a deficiency (incl 1, para 1.1).

7.5 Heading and Attitude Reference System (HARS)

7.5.1 General. HARS alignment times as a function of temperature is presented in incl 3, table 3-7 for the normal and fast modes. Normal and fast alignment modes were not normally conducted during the same test run except in cases where a normal alignment was tried and the system failed to align. Two HARS were required to complete the Climatic Survey. The first HARS failed at -50°F (-45.6°C) after several runs at -25°F (-32.7°C). When the second HARS was installed, it produced an oscillatory heading at -25°F (-31.7°C). The second HARS was never exposed to -50°F (-45.6°C), but had been exposed to +125°F (+51.7°C).

7.5.2 At +70°F (+21.1°C), incl 3, table 3-7, shows that the HARS (2nd one) would normal align in 8.6 minutes. No data is available for fast alignment times at +70°F (+21.1°C), although no problems were noted. At +16°F (-8.8°C) the HARS would fast align on the first attempt. At -25°F (-31.7°C) the system would not normal align but a fast alignment could be achieved on the second attempt (cycle) in the fast mode. Fast alignment times (4.5 to 7.5 minutes) presented for the second cycle do not inlcude the first cycle time. With the second HARS at -25°F (-31.7°C), heading differences of 10 degrees were observed and later went oscillatory (270-295 deg vs a magnetic compass heading of 305 deg). After the headings went oscillatory, a second fast alignment was completed in 7.5 minutes. This HARS was later removed and returned to service at Yuma Proving Ground on another YAH-64. At -50°F (-45.6°C) the HARS would neither normal or fast align and was replaced prior to proceeding to the +125°F (+51.7°C) test environment.

7.5.3 Due to the importance of the HARS for providing heading and attitude information to the aircraft and mission equipment, the failure to properly align in all modes and the system reliability at cold temperatures is considered to be a deficiency (incl 1, para 1-1).

7.6 Area Weapon System (AWS)

7.6.1 The AWS, as installed on the test aircraft, did not include the latest gun/feed system (incl 3, table 3-8) and the latest electrical components (gun control box). During initial presurvey slewing checks, the gun transfer housing and system were broken when the gun was slewed to the limits. This was repaired and care was exercised during the survey to preclude going to the mechanical limits to avoid further breakage. Item 7 of incl 3, table 3-8, indicates an improvement in the latest configuration. Apparently, sofeware programming was not included to preclude such malfunction. Based on this problem, a GUN LIMITS envelope was provided for the survey by the contractor and is presented in figure 3-7.

7.6.2 Instrumentation problems precluded evaluation of the gun slew rates and tracking at the various test temperatures. Live firing was not conducted but a total of 478 rounds of dummy ammunition was cycled at the test temperatures shown in incl 3, table 3-9, except at +125°F (+51.7°C) due to aircraft mission equipment problems. All gun cycling was performed at the end of the test run with only the APU operating.

7.6.3 At -25°F (-31.7°C), it was noted that the AWS would intermittently not track the TADS. This was physically observed in that the TADS would be positioned looking left and the gun would be positioned pointed to the right. This intermittent tracking was considered to be a shortcoming (incl 1, para 1-2), in that the crew has no way of actually knowing if the gun is tracking or its position. The malfunction was considered to be temperature related and the contractor suspected the gun control box (EPR KF-23). The slewing tests were conducted with the rotors turning.

7.6.4 Another problem noted was that the AWS would continue to cycle 1 to 1½ seconds after trigger release (EPR KF-58). This was first observed after the first cold soak to -25°F (-31.7°C), but was later observed at test temperatures of +70°F (+21.1°C), +125°F (+51.7°C), and -25°F (-31.7°C) again. Again, the gun control box was not of the production configuration.

7.7 Integrated Helmet and Display Sight Subsystem (IHADSS)

7.7.1 The IHADSS was primarily inoperative throughout the survey until the last two test runs (+125°F (+51.7°C) and -25°F (-31.7°C). The system was not initially prepared for the survey and recurring problems (EPR KF-50) were found with the Sensor Surveying Units (SSU) and the helmet display unit had mechanical problems (EPR KF-51).

7.7.2 At +125°F (+51.7°C), an IHADSS fail message was displayed in the aft crew station and the IHADSS would not boresight. The CPG and pilot had an invalid line-of-sight message and the Fault Detection/Location System (FD/LS) indicated

IHADSS No-Go. Further FD/LS checks showed that the pilot's right sensor survey unit (SSU) had failed. Further investigation indicated that a short existed in the SSU connecting plug. No abnormalities occurred during the following -25°F (-31.7°C) test run.

7.7.3 In summary, the IHADSS would probably have operated satisfactorily if properly set up prior to the survey. Further evaluation should be conducted to evaluate the response of the Sensor Surveying Units to various temperatures.

7.8 External Stores/Pylons

7.8.1 Evaluation of the external stores/pylon system was limited to physical observations of movement and operation. Instrumentation was not available to record pylon position. Operation was satisfactory for the missile and rocket systems except for the following:

7.8.1.1 At +70°F (+21.1°C), the left inboard missile launcher failed BIT. A fault was found in the wing store pylon and the pylon was replaced (EPR KF-2).

7.8.1.2 An electrical short occured in the pylon wiring (EPR KF-30).

7.8.2 Random pylon articulation was initially noted at +125°F (+51.7°C), but would later occur at +70°F (+21.1°C) and -25°F (-31.7°C), indicating a hard failure at that initial temperature (EPR KF-65). It was noted that the symbology displayed airspeed cycled from 0 to 100 knots during articulation. The Air Data Sensor had been disconnected and the contractor related the problem to the possibility of the Doppler going in and out of memory although the test team never noted indication of the memory light.

7.9 Fault Detection/Location System (FD/LS)

7.9.1 The FD/LS was only partially integrated for the Climatic Survey. The TADS/PNVS did not provide any input to the FD/LS and the FD/LS "flashing" message on the displays was not incorporated. Interrogation of the FD/LS could be performed by running a "GSTAT" end-to-end test.

7.9.2 Systems that were incorporated in FD/LS and appeared to work satisfactorily throughout the survey were the fire control computer, missile, rocket, air data sensor, and IHADSS systems.

7.10 TADS/PNVS Anti-Ice System

7.10.1 General. The Climatic Laboratory Survey was an initial "on-board" operational test of this system. Data acquired was to provide information to determine if any changes might be required prior to follow-on icing tests. Due

to overall TADS/PNVS problems, only limited data was acquired at -25°F (-31.7°C). No data was acquired at -50°F (-45.6°C) due to the inability to turn the TADS/PNVS system on.

7.10.2 PNVS. The PNVS uses a thermister to control voltage across the germanium window heater. The thermister is temperature sensitive and should maintain 58 VAC rms across the window. For follow-on icing tests, the window temperature should be maintained at +85°F (+29.4°C) to +90°F (+32.2°C). During the Climatic Laboratory Survey the set point temperature was set at approximately +75°F (+23.8°C) to protect the window during initial testing. Tests indicated that some problems may exist in the temperature control system.

7.10.3 TADS Night Side. Voltage across the TADS night side window should be approximately 65 VAC rms and temperature should be maintained at +85°F (+29.4°C) to +90°F (+32.2°C) for anti-icing. During the Climatic Laboratory Survey, the temperature reached approximately +104°F (+40°C). This temperature level was too high and should be decreased for normal operation. Tests indicated a decrease of approximately 1/2 volt (+9°F (-12.7°C)) with the aircraft rotors turning, possibly due to air flow characteristics, which produced a temperature shift on the lower day side and night side windows. It is presently unknown if this characteristic will be evident in flight.

7.10.4 TADS Day Side. Voltage across the TADS day side window should be approximately 115 VAC rms (130 VAC for worst icing conditions) and the set point temperature for the upper and lower windows should be +120°F (+48.8°C). The set point temperature should be increased as tests indicated upper and lower window temperatures of approximately +90°F (+32.2°C) and +110°F (+43.3°C) respectively. The bottom window cracked during the survey during an ambient temperature transition from -50°F (-45.6°C) to +125°F (+51.7°C). This window failure was attributed to the test window being modified with a "lip" along the outer edge for installation purposes which allowed thermal stress to occur. Later versions are said to not incorporate this feature and will be a full plate window.

7.11 Point Target Weapon System (PTWS)

7.11.1 The PTWS was evaluated only as to its function, utilizing a training missile, and its capability to perform a simulated lock-on-after-launch (LOAL) firing. An external laser source was not available for the survey, precluding any lock-on-before-launch (LOBL) sequences. The training missile was mounted just prior to sequence simulation so that the missile components would not be heat or cold soaked. Due to the installed missile system being an early configuration (not production), the system would not function using normal procedures. The Remote Hellfire Electronics (RHE) circuit breaker (labeled AC ELEC) had to be cycled to allow the system to reinventory, to allow bypass of the launcher Fail Bit messages, and to allow the system to achieve launch constraints.

7.11.2 The missile system functioned normally at +70°F (+21.1°C) and -25°F (-31.7°C). At -50°F (-45.6°C), the system would not pass BIT (EPR KF-39). Several attempts were made; finally the missile fail caution light illuminated. This failure to pass BIT was suspected due to HARS nonalignment. At +125°F (+51.7°C), which followed the -50°F (-45.6°C) test run, the RHE failed (EPR KF-47). The missile fail caution light illuminated and the FD/LS indicated No-Go. It is suspected that failure of the RHE may have actually occurred at -50°F (-45.6°C).

7.12 Air Data Sensor System (ADS)

The ADS system as provided to the Climatic Laboratory Survey was not operational due to an improper air data processor. Whenever the ADS was turned on, the aircraft stabilator would fail. The system was only briefly turned on at all test temperatures to visually insure that the omnidirectional airspeed sensor (OAS), located on top of the stationary mast, would rotate. No data is available to ascertain if the OAS was turning at the correct speed.

7.13 Lightweight Doppler Navigational System (LDNS)

The LDNS was only tested for program retention. The LDNS was programmed at the beginning of the test and memory was retained throughout all temperatures tested.

7.14 Human Factors Characteristics

7.14.1 General. Human factors characteristics were obtained based on the ability of the Environmental Control Unit (ENCU) to provide an adequate environment in extremely cold (-25°F (-31.7°C), -50°F (-45.6°C)) and extremely hot (+125°F (+51.7°C)) ambient temperatures. The performance of the ENCU was evaluated against the requirements specified in MIL-STD-1472B, section 5.8.1 and general human factors design considerations. Airflow velocity data were obtained with a hot wire anemometer placed 8 to 10 inches (23.3 to 25.4 cm) from the left and right instrument panel ducts in the pilot's and CPG's station, 8 to 10 inches (23.3 to 25.4 cm) from the floor ducts in the CPG's station, at the cyclic grip in the pilot's station, and in the slots which allow fore and aft travel of the pilot's antitorque pedals. Temperature measures were also obtained at these locations using a digital thermometer. In addition, each of the three pilots was interviewed following their flights in extreme cold temperatures and extreme hot temperatures to determine the capability of the ENCU to maintain a comfortable environment.

7.14.2 Cockpit Temperature and Airflow. Temperature and airflow measurements are presented in incl 3, tables 3-10 through 3-13. The temperature and airflow data taken at the pilot's cyclic grip are most representative of these experienced by the upper body. No significant airflow velocity problems exist at

this location in extremely cold external conditions. Temperatures at this location, however, are below the minimum of +50°F (+10°C) specified for personnel-occupied enclosures in MIL-STD-1472B, paragraph 5.8.1.1, in all flight modes except with rotor stopped. Airflow measurements at the pedal travel slot (fig 3-8) in the pilot's floor greatly exceed the specified 100 feet per minute limit (MIL-STD-1472B, para 5.8.1.2). Temperatures at this location are well below the required +50°F (+10°C) temperature. With rotor stopped, however, temperatures at these slots are above the specified temperature (incl 3, table 3-10, -25°F ambient temperature), indicating that the temperature problem is probably caused by cold external air rapidly entering through these slots during flight modes. This introduction of cold air contributes to the inability of the ENCU to keep the cockpit warm. Pilot comments concur with these findings and indicate that the problem becomes worse as more torque is applied. The current configuration is regarded as a shortcoming (incl 2, para 1-2) because the extreme cold temperatures within the cockpit could have a debilitating effect on pilot efficiency, performance, and safety due to the probability of frostbite. Pilot comments also indicate that with hot external conditions, hot air enters through the pedal travel slots in the pilot's floor. These high temperatures lead to such problems as excessive perspiration from the head running into the eyes, "hot spots" on the seat back and bottom, and general discomfort.

7.14.3 Flow Restrictors. When the ENCU is first turned on, no heat is available, and cold air is blown through the cockpit. No flow restrictors were installed in the CPG's head vents, preventing him from stopping this flow of cold air (which blows directly on the crewmember) until the ENCU began producing heat. Crewmembers cannot remove their hands from the large mittens and begin the preflight checklist and programming procedures by manipulating switches, controls, etc., until the cockpit warms up. The lack of adequate flow restrictors is considered a shortcoming (incl 1, para 1-2) due to the induced chill factor.

7.14.4 Restraint System. The bulkiness of the external flight parka and arctic boots made ingress/egress difficult. A safety hazard also occurs for large individuals (approximately 90th percentile) when wearing the parka because insufficient adjustment exists in the restraint system to buckle it over the parka. It must be fastened under the parka, making quick release difficult in an emergency. In addition, no adjustment exists in the anti-submarine strap (between the legs). When wearing the parka, the crewman is raised in his seat, lowering the placement of the five-point buckle toward the crotch which may effect the restraining characteristics of the system. The lack of sufficient adjustment to accommodate the 90th percentile aviator in arctic clothing is considered a shortcoming (see AEFA report).

7.14.5 Chemical or Biological Environment. The inability of the cooling system to maintain the work environment at or below +85°F (+29.4°C) will have its heaviest impact during operations in a chemical or biological environment. The

use of the NBC protective mask, hood, boots, gloves, and outer garment will further aggravate the discomfort problems encountered during this test.

7.15 Environmental Control Unit (ENCU)

7.15.1 The ENCU would not provide adequate heated/cooled air at -25°F (-31.7°C), -50°F (-45.6°C), and +125°F (+51.7°C). Although the ENCU is not considered a part of the mission equipment or armament systems, its performance has a significant impact on the overall system operation. Areas impacted by its performance were the pilot and CPG cockpits from a human factors consideration (para 7.14), TADS/PNVS operation (para 7.2 and 7.3), and the forward avionics bays (FABS). The inability of the ENCU to provide the proper conditioning and its failure to meet system specification requirements at these temperatures (see AEFA portion of report) were considered a major deficiency.

7.15.2 A significant number of the deficiencies and shortcomings (incl 1, para 1.1 and 1.2) can be directly related to the inadequacy of the ENCU. At the cold temperatures, overall system prechecks are temporarily precluded due to the symbol generator excessive warm-up time, effect on the FCC and HARS reliability, and capability to operate the TADS/PNVS below -25°F (-31.7°C). At +125°F (+51.7°C), the overall TADS/PNVS and weapon systems were inoperative after 56.5 minutes of operation. At -50°F (-45.6°C), approximately one hour was required prior to system operation (para 7.2.2.4) due to the inability of the ENCU and system to provide +40°F (+4.4°C) air to the TADS air inlet. Based on heat-sensitive tape tabs, at +125°F (+51.7°C), the TADS EU-1 external temperature reached +160°F (+71.1°C) and the RHE reached +140°F (+60°C). Both are located in the FABS (incl 3, figs 3-5 and 3-6). A summary of the FABS inlet air temperature is presented in incl 3, table 3-4. Time histories are presented in incl 3, figures 3-1 through 3-4.

7.16 Maintenance Data

Maintenance was performed by the contractor. Maintenance data is not presented except for the description of the EPR (incl 2, table 2-1), which were previously distributed to the test project manager during the conduct of the test. An assessment as to whether the EPR related malfunction is temperature related and the associated "follow-up" action is also included. These assessments were made following the Climatic Laboratory Survey by a combined group of Army Program Manager's personnel, Hughes Helicopters, Martin Marietta and the USAAVNDTA Test Team. Additional information by the USAAVNDTA Test Team are presented in the remarks column.

8. CONCLUSIONS

8.1 The Climatic Laboratory Survey was conducted with a competition development TADS/PNVS system which had several unique operational characteristics not

representative of the production units. The associated mission equipment, in several cases, did not incorporate the latest components or circuitry and, some components and systems were not complete or were inadequately prepared for the evaluation.

8.2 A significant number of the deficiencies and shortcomings (Human Factors and Mission Equipment) can be directly related to the inadequacy of the ENCU (incl 1, para 1-1 and 1-2). The ENCU did not meet system specification requirements at -25°F (-31.7°C), -50°F (-45.6°C), and +125°F (+51.7°C).

8.3 Cold weather operation at -25°F (-31.7°C) and below may be precluded due to the unreliability of the FCC and HARS.

8.4 The excessive symbol generator warm-up time precludes a quick-reaction capability at -25°F (-31.7°C) and below.

8.5 The YAH-64 mission equipment cannot adequately function at +125°F (+51.7°C) with the present environmental conditioning available.

8.6 TADS operation, within a reasonable timeframe, was precluded at -50°F (-45.6°C) due to the inability of the ENCU to provide the required +40°F (+4.4°C) heated air to the TADS.

8.7 Temperature extremes did not appear to affect FD/LS operation for the systems that were incorporated.

8.8 Based on limited testing, the TADS/PNVS anti-ice system appeared to be satisfactory at -25°F (-31.7°C) with some minor modifications required.

8.9 Five deficiencies were noted (incl 1, para 1-1).

8.10 Eleven shortcomings were noted (incl 1, para 1-2).

9. RECOMMENDATIONS

9.1 Deficiencies and shortcomings be corrected prior to production.

9.2 Climatic Laboratory testing be conducted with production systems installed.

9.3 Determine if laser pulse rate (coding) changes as a function of temperature.

10. AUTHORS

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DEFICIENCIES AND SHORTCOMINGS

1-1. Deficiencies

1. The fire control computer (FCC) was unreliable.

   a. Lost memory twice at $-25^{o}F$ ($-31.7^{o}C$).

   b. Malfunctioned once at $-50^{o}F$ ($-45.6^{o}C$).

   c. Lost or changed navigational data, precluding proper waypoint targeting operation; initially noted at $+125^{o}F$ ($+51.7^{o}C$).

   d. Appears that the FCC should be removed and kept warm prior to operation at cold temperatures.

   e. FCC replaced three times during survey and fourth FCC was malfunctioning prior to end of survey.

2. The YAH-64 symbol generator (YSG) required an excessive warm-up time at cold temperatures.

   a. $+125^{o}F$ ($+51.7^{o}C$) - instantaneous.

   b. $+70^{o}F$ ($+21.1^{o}C$) - instantaneous.

   c. $+10^{o}F$ ($-12.2^{o}C$) - 3.3 minutes.

   d. $-25^{o}F$ ($-31.7^{o}C$) - up to 24 minutes.

   e. $-50^{o}F$ ($-45.6^{o}C$) - preheat required.

3. The heading and attitude reference system (HARS) was unreliable:

   a. Would not normal align at $-25^{o}F$ ($-31.7^{o}C$) after 30 minutes.

   b. Fast align required two cycles at $-25^{o}F$ ($-31.7^{o}C$).

   c. Second cycle at $-25^{o}F$ ($-31.7^{o}C$) required 4.5 to 7.5 minutes for alignment.

   d. The first HARS failed to normal or fast align at $-50^{o}F$ ($-45.6^{o}C$) and was replaced.

   e. The second HARS failed to provide correct heading information at $-25^{o}F$ ($-31.7^{o}C$).

4. The environmental control unit (ENCU) did not provide adequate heated/cooled air to the cockpit, TADS, and FABS at $-25^{o}F$ ($-31.7^{o}C$), $-50^{o}F$ ($-45.6^{o}C$), and $+125^{o}F$ ($+51.7^{o}C$).

5. The TADS/PNVS and weapon systems did not adequately function at $+125^{o}F$ ($+51.7^{o}C$).

1-2. Shortcomings

1. TADS/PNVS power supply 28VDC circuit breaker would trip at +16°F (-8.8°C) and below.

2. The heads up display video compression was a function of temperature.

3. Day television camera failed at +125°F (+51.7°C).

4. DVO boresight system would not spiral at -25°F (-31.7°C).

5. The laser was intermittent as a function of temperature decrease.

6. The intermittent tracking of the 30mm gun with the TADS.

7. The remote hellfire electronics (RHE) failed at +125°F (+51.7°C).

8. The random articulation of the pylons.

9. The excessive airflow through the tailrotor pedal slots.

10. The TADS bottom day side window cracked during transition from -50°F (-45.6°C) to +125°F (+51.7°C).

11. The lack of flow restrictors in cockpit vents allows large quantities of cold air to enter when the ENCU is first started.

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-7	20Nov81	HMD/TADS would not couple. Could not be duplicated.	+70	No	Random occurrence - no action.	
KF-8	20Nov81	TADS control lost when PNVS switched to NVS - could not be duplicated.	+70	No	Random occurrence - no action.	
KF-9	20Nov81	RMS circuit breaker had to be cycled to simulate LOAL launch.	+70	No	Not production configuration - failure analysis and review HHI/Army.	
KF-10	23Nov81	Fire Control Computer (FCC) lost memory (Bite indicator noted).	-25	Yes	Not production configuration - failure analysis and review HHI/Army.	
KF-11	23Nov81	IHADSS will not accept boresight.	-25	No	Deficient CD items - HDU failure analysis and review - HHI/Army.	
KF-12	23Nov81	TADS DTV has EMI when PNVS is on - previously described as a phase-lock loop problem as evident on earlier systems (CD).	-25	No	Not production configuration - qualification not complete - no action.	
KF-13	23Nov81	HMD/TADS would not couple.	-25	No	Random occurrence - no action.	See EPR number KF-7.
KF-14	23Nov81	TADS gray scale will not produce useable HUD or HDD video.	-25	No	Not production configuration - (IVD electronics) qualified - no action.	System delivered to test in this condition.
KF-14-S-1	23Nov81	TADS gray scale.	All	No	See KF-14	

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR)

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-1	19Nov81	TADS FLIR loses boresight vector. Required abnormal checklist procedure.	+70	No	Random occurrence - "p" and production system corrects problem (digital tracker) and automatic boresight - no action required.	Peculiar to competition development system which test was conducted with.
KF-2	19Nov81	Wing stores pylon malfunction.	+70	No	Random occurrence - no action.	
KF-3	19Nov81	30mm gun when slaved to TADS would not cycle except on fixed forward position.	+70	No	Possible operator error - no action.	See KF-3-S-1
KF-3-S-1	19Nov81	30mm gun (information on KF-3).	+70	No	NA	
KF-4	20Nov81	Multiplex Remote Terminal Unit (MRTU) (Type 1) failed.	+70	No	Random occurrence - analysis to be done - review HHI/Army.	
KF-5	20Nov81	Alpha Numeric Display (AND) intermittently blinks.	+70	No	Cause under ivestigation - failure analysis.	System delivered to test in this condition - never repaired by contractor during test.
KF-5-S-1	12Dec81	Alpha Numeric Display (AND) flasher at a high frequency rate.	+70	No	MMC/HHI/Army review.	
KF-6	20Nov81	Heads Down Display (HDD) has poor quality video.	+70	No	Deficient CD item - not production item - no action.	System delivered to test in this condition - never repaired by contractor during test.
KF-6-S-1	20Nov81	Heads Down Display (HDD) info that HDD deficient.	All	No	See KF-6.	

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment		
				Temp Related	Actions Required	Remarks
KF-15	23Nov81	Air Data Sensor system not complete.	All	No	Air Data processor incomplete - HHI to research reason for configuration - action HHI.	System delivered to test in this condition. Never repaired during Climatic Survey.
KF-16	23Nov81	IHADSS HDU combiner lens chipped.	All	No	Received chipped - review CPG HDU bolster location - HHI/ Honeywell/Army review chip history.	
KF-17	25Nov81	CPG could not monitor TADS symbology or video with pilot in command of TADS.	-25	Yes	Random - not repeatable - no action.	
KF-18	25Nov81	TADS HDD video compressed.	-25	Yes	System unique - review and analysis MMC/Army.	
KF-18-S-1	12Dec81	TADS HDD video compressed. Compression changed as a function of temperature.	+70	Yes	See EPR number KF-18.	
KF-19	25Nov81	TADS DVO could not be boresighted.	-25	Yes	CD unit unique - corrected in "P" and production - no action required.	In addition to non-spiraling of boresight, this ORT was CD but DVO portion did not include a lighted reticle for boresighting.
KF-19-S-1	13Dec81	TADS DVO boresight would not spiral properly.	-25	Yes	See EPR number KF-19.	
KF-20	25Nov81	TADS intermittently loses FLIR boresight vector.	-25	No	Unique to CD configuration - corrected in production - no action required.	CD version uses analog tracker. See EPR number KF-1.

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KP-15	23Nov81	Air Data Sensor system not complete.	All	No	Air Data processor incomplete - HHI to research reason for configuration - action HHI.	System delivered to test in this condition. Never repaired during Climatic Survey.
KP-16	23Nov81	IHADSS HDU combiner lens chipped.	All	No	Received chipped - review CPG HDU holster location - HHI/Honeywell/Army review chip history.	
KP-17	25Nov81	CPG could not monitor TADS symbology or video with pilot in command of TADS.	-25	Yes	Random - not repeatable - no action.	
KP-18	25Nov81	TADS HHD video compressed.	-25	Yes	System unique - review and analysis MMC/Army.	
KP-18-S-1	12Dec81	TADS HHD video compressed. Compression changed as a function of temperature.	+70	Yes	See EPR number KP-18.	
KP-19	25Nov81	TADS DVO could not be boresighted.	-25	Yes	CD unit unique - corrected in "P" and production - no action required.	In addition to non-spiraling of boresight, this GRT was CD but DVO portion did not include a lighted reticle for boresighting.
KP-19-S-1	13Dec81	TADS DVO boresight would not spiral properly.	-25	Yes	See EPR number KP-19.	
KP-20	25Nov81	TADS intermittently loses FLIR boresight vector.	-25	No	Unique to CD configuration - corrected in production - no action required.	CD version uses analog tracker. See EPR number KP-1.

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-28-S-1	15Dec81	EPR numbers KF-36 and KF-36-S-1 should have been supplements to KF-28.	-25	Yes	See EPR numbers KF-36 and KF-36-S-1.	
KF-29	27Nov81	PNVS stow (deleted).	+16	-	Deleted.	
KF-30	27Nov81	Pylon wires electrically shorted.	+16	No	Random occurrence - no action.	
KF-31	1Dec81	Primary MUX caution light - FCC malfunction (no BITE indicated).	-50	No	Shorted FCC power supply - random - no action.	
KF-32	1Dec81	TADS ECS blower wiring not correct (deleted).	-50	-	Deleted.	Improper wiring installation.
KF-33	3Dec81	Symbol generator did not provide useable symbology.	-50	Yes	See EPR number KF-27.	
KF-34	3Dec81	HARS would not normal or fast align.	-50	Yes	Not production unit - review production qual plan to insure proper coverage - HHI/Army.	Unit replaced.
KF-34-S-1	15Dec81	HARS would not maintain alignment with the magnetic compass.	-25	Yes	Failure analysis required - currently operating at YPG - action HHI/Army.	This was replacement unit noted in EPR number KF-34 remarks.
KF-35	3Dec81	ENCU inadequately heated air to TADS. Required one hour prior to turn on.	-50	Yes	Not production unit - redesign not approved - action HHI/Army.	Only design changed presently forecasted by HHI is a redesigned distribution system. Total concept not yet Army approved.
KF-36	4Dec81	TADS inoperative - tripped TADS power supply 28VDC circuit breaker.	-50	Yes	See EPR number KF-28.	

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-28-S-1	15Dec81	EPR numbers KF-36 and KF-36-S-1 should have been supplements to KF-28.	-25	Yes	See EPR numbers KF-36 and KF-36-S-1.	
KF-29	27Nov81	PNVS stow (deleted).	+16	-	Deleted.	
KF-30	27Nov81	Pylon wires electrically shorted.	+16	No	Random occurrence - no action.	
KF-31	1Dec81	Primary MUX caution light - FCC malfunction (no BITE indicated).	-50	No	Shorted FCC power supply - random - no action.	
KF-32	1Dec81	TADS ECS blower wiring not correct (deleted).	-50	-	Deleted.	Improper wiring installation.
KF-33	3Dec81	Symbol generator did not provide useable symbology.	-50	Yes	See EPR number KF-27.	
KF-34	3Dec81	HARS would not normal or fast align.	-50	Yes	Not production unit - review production qual plan to insure proper coverage - HHI/Army.	Unit replaced.
KF-34-S-1	15Dec81	HARS would not maintain alignment with the magnetic compass.	-25	Yes	Failure analysis required - currently operating at YPG - action HHI/Army.	This was replacement unit noted in EPR number KF-34 remarks.
KF-35	3Dec81	ENCU inadequately heated air to TADS. Required one hour prior to turn on.	-50	Yes	Not production unit - redesign not approved - action HHI/Army.	Only design changed presently forecasted by HHI is a redesigned distribution system. Total concept not yet Army approved.
KF-36	4Dec81	TADS inoperative - tripped TADS power supply 28VDC circuit breaker.	-50	Yes	See EPR number KF-28.	

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-45	5Dec81	TADS bottom day side glass cracked.	Transition -50 to +125	Yes	Not a production unit - icing test windows/heaters represent production.	Appears that thermal stress was introduced due to mounting/installation lip on glass.
KF-46	8Dec81	IHADSS inoperative.	+125	No	See EPR number KF-38.	IHADSS inop may have been produced by temperature related failures of SSU.
KF-47	5Dec81	Remote HELLFIRE Electronics (RHE) failed.	+125	Yes	Not a production unit - failure analysis required - see also EPR numbers KF-9 and KF-39.	
KF-48	8Dec81	PNVS (deleted).	+125	-	Deleted.	
KF-49	8Dec81	TADS EU-2 box suspected failure, checked and reinstalled.	+125	NA	Unit found to be okay - used for troubleshooting - no action.	MM stated that the EU-2 box was probably not adequately cooled at this test temperature.
KF-50	8Dec81	Pilot's right SSU inoperative.	+125	Yes	See EPR numbers KF-38 and KF-46.	
KF-51	12Dec81	IHADSS would not command PNVS.	+70	No	See EPR numbers KF-38, KF-46 and KF-50.	- combiner lens sliding clip bent. - combiner lens collar loose on CRT unit. - bad ground wiring on HDU. NOTE IHADSS maintenance personnel arrived this date to fix inoperative IHADSS system.
KF-52	12Dec81	Laser intermittent. (Fire Control Panel replaced)	+70	No	Failure analysis required - HHI/Army review.	Suspect failure actually occurred at previous +125°F test temperature. (See KF-57)

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-53	12Dec81	TADS FLIR boresight LAT gates would not capture boresight cue.	+70	No	See also EPR numbers KF-1 and KF-26.	
KF-54	12Dec81	LDNS (deleted).	+70	No	Deleted.	
KF-55	12Dec81	TADS FLIR stuck in WFOV.	+70	No	CD unique - see also EPR number KF-26.	
KF-55-S-1	14Dec81	TADS FLIR would not change FOV.	+125	No	CD unique - see also EPR number KF-26.	
KF-56	12-15Dec81	FCC changes GRID zone data presented as inaccurate waypoint slaving to target.	+125, -25, +70	Yes	Failure analysis and review required HHI/Army.	
KF-56-S-1	15Dec81	FCC lost aircraft position, initial readouts were all zeros and ones.	-25	Yes	Failure analysis and review required HHI/Army.	
KF-57	12Dec81	Fire Control Panel (FCP) malfunction.	+70	No	Failure analysis and review required HHI/Army.	Suspect that malfunction actually occurred at previous +125°F test run and is temperature related.
KF-58	12Dec81	30mm gun continues to cycle 1-1½ seconds after trigger release.	+70	No	Not production gun control box - recheck during icing tests - action HHI.	Mechanical and electrical components were not of the latest configuration.
KF-59	14Dec81	Heads Down Display (HDD) inoperative.	+125	Yes	CD display - cockpit was overtemp - production unit completed qual at 130°F - (IVD elec) - review for potential design problem - action HHC/Army.	Following "cool down" of hangar, system was checked at approximately +36°F and was found operable.

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment: Temp Related	Assessment: Actions Required	Assessment: Remarks
KF-60	14Dec81	Heads Up Display on ORT had compressed video and symbology.	+125	Yes	See EPR number KF-59.	See EPR number KF-59 remarks.
KF-61	14Dec81	TADS system failed after 56.5 minutes of operation.	+125	Yes	Not production design - circuit analysis to determine probable cause - action MMC/Army.	See EPR number KF-59 remarks.
KF-62	14Dec81	PNVS control lost.	+125	Yes	Insufficient cooling air - related to ENCU (see AEFA report)	See EPR number KF-59 remarks.
KF-63	14Dec81	Weapon systems could not be slaved.	+125	Yes	Not currently repeatable - monitor during icing tests - action HHI/Army.	See EPR number KF-59 remarks. **NOTE** Disagree that malfunction is not repeatable. System was never returned to +125°F for additional tests.
KF-64	14Dec81	Day Television (DTV) camera video deterioration.	+125	Yes	Failure analysis required - MMC/Army review.	
KF-64-S-1	15Dec81	Day Television (DTV) camera inoperative.	-25	Yes	See EPR number KF-64.	**NOTE** Deterioration started at +125°F.
KF-65	12Dec81	Wing pylons articulate at random.	+70, +125, -25	No	Failure analysis/installation definition required - HHI/Army review.	Noted that displayed airspeed cycled from 0 to 100 kts during random articulation. HHI stated that articulation due to LDNS going in and out of memory. Test team believes that further investigation required.

TABLE 2-1. EQUIPMENT PERFORMANCE REPORTS (EPR) continued

EPR No.	Date	Description	Temp (°F)	Assessment		
				Temp Related	Actions Required	Remarks
KP-66	14Dec81	FC-16 switch scrambles PNVS video and symbology.	+125	Yes	Circuit analysis required to determine probable cause - MMC/Army review.	
KP-67	15Dec81	PNVS anti-ice inoperative (deleted).	-25	-	Deleted.	System not connected by maintenance personnel.
KP-68	12Dec81	"Failed Keyboard" message displayed on AMD. Regained after cycling the FC-AC circuit breaker.	-25	No	Not production circuit - ECRR prepared - HHI/Army review.	

DETAILED TEST DATA

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Incl 3

Table 3-1. Test Matrix

Date	Run No./Test No.	Temperature	Remarks
12 November	1/NA	Ambient	APU Run
13 November	2/880	Ambient	Shakedown Run
16 November	---	---	Accepted Aircraft
16 November	3/881	+70°F	Data Run
19 November	4/884	+70°F	Data Run
20 November	5/885	+70°F	Data Run
23 November	6/886	-25°F	Data Run
24 November	7/887	-25°F	Attempted
25 November	8/888	-25°F	Data Run
27 November	9/889	-25°F	Data Run
28 November	---	+10°F to +16°F	Maintenance Run
1 December	10/891	-50°F	Data Run
2 December	11/892	-50°F	Data Run
3 December	12/893	-50°F	Data Run
4 December	13/894	-50°F	Data Run
7 December	---	+125°F	Shakedown
8 December	14/895	+125°F	Attempted
8 December	---	Maintenance	Returned to HH
12 December	15/897	Ambient (+70°F)	Maintenance Run
14 December	16/898	+125°F	Data Run
14 December	---	+36°F	System Check
15 December	17/899	-25°F	Data Run

TABLE 3-2. TADS SYSTEM CHARACTERISTICS AND INADEQUACIES AS DELIVERED

Item	System Unique	Corrected Prior to Test Starting	Never Corrected
1. Competition Development (CD) System.	X		
2. Turret day side shroud was improperly fitted.		X	
3. Optical relay tube was CD but DVO portion was precompetition.	X		
4. The AND was scrambled.			X
- the missile inventory status was printed in the wrong line sets.			X
- alpha characters were printed over the top of other characters.			X
- the AND blinked on/off continuously.			X
5. Heads Down Display			
- poor quality video, display scene was not clean and crisp.			X
6. Heads Up Display			
- vertical compression of about 10% of the display.			X
- when adjusted at ten shades of gray, produced unuseable video for turret deployed scanning.			X
- brightness and contrast had to be adjusted on a scene for useable video.			X

TABLE 3-2. TADS SYSTEM CHARACTERISTICS AND INADEQUACIES AS DELIVERED (Con't)

Item	System Unique	Corrected Prior to Test Starting	Never Corrected
7. DVO optics			
- poor quality			X
- video appeared to have a grease film over optics.			X
- no DVO reticle lighting which made orientation more difficult and "out front" boresight checks difficult (representative of early phase system).			X
8. DVO boresight (early phase system)			
- no DVO reticle lighting which made orientation more difficult and "out front" boresight checks difficult.	X		
9. FLIR boresight			
- the FLIR boresight vector was not retained causing boresight to be completed using an alternate work-around (non-standard) checklist procedure.	X		
10. FLIR gain control was inoperative			X
11. FLIR had horizontal "dead" bands through the field of view of the video display			X

TABLE 3-2. TADS SYSTEM CHARACTERISTICS AND INADEQUACIES AS DELIVERED (Con't)

Item	System Unique	Corrected Prior to Test Starting	Never Corrected
12. Day television EMI - when the aft crew member selected PNVS the TADS video became very jumpy from a phase-lock loop sync phenomenon causing the TV scene to be unuseable.	X		
13. TADS/HMD deslave. The TADS would not deslave from the IHADSS in HMD/TADS by use of the slave switch on the ORT handgrip. To deslave, the sight select switch had to be moved from HMD/TADS to standby.	X		
14. TADS laser appeared to be weak.			X

Table 3-3. TADS Air Inlet Summary

Test Temperature / Parameter	-25° F/-31.7° C			-50° F/-45.6° C		$+70^{\circ}$ F/$+21.1^{\circ}$ C			$+125^{\circ}$ F/$+51.7^{\circ}$ C	
Run No./Test No.	6/886	8/888	17/899	12/893	13/894	4/884	5/885	15/887	14/895	16/898
Time to achieve steady state temperature from ENCU on ~ min.	NA	35.0	30.0	49	2 13.8	23.2	NA	NA	5.0	5.0
Time steady state temperature maintained before changing ~ min.	NA	65.0	65.0	30.0	50.0	No change	NA	NA	NA	NA
Steady state temperature ~ ° C	+14.0	+25.0	+25.0	0.0	0.0	+21.0	+25.0	+20.0	+35.0	+38.0
Final temperature achieved (end of data run) ~ ° C	+27.0	+35.0	+35.0	+8.0	+32.0	+21.0	+25.0	+20.0	+35.0	+38.0
Time to achieve final temperature from ENCU on ~ min.	NA	117.0	109.0	84.0	106.3	NA	NA	NA	96	

NOTES:
1. Data derived from figures III-1 through III-10, inclosure III.
2. Initial PAS air provided by external air source.

Table 3-4. Forward Avionics Bays Inlet Air Temperature Summary

Test Temperature / Parameter	-25° F/-31.7° C						-50° F/-45.6° C				+70° F/+21.1° C						+125° F/+51.7° C			
Run No./Test No.	6/886		8/888		17/899		12/893		13/894		4/884		5/885		15/887		14/895		16/896	
FAB	LF	RT	LF	RT	LF	RT	LF	RT	LF	RT [2]	LF	RT	LF	RT	LF	RT	LF	RT	LF	RT
Time to achieve steady state temperature from ENCU on ~ min.	NA	NA	32.0	34.0	27.0	27.0	56.5	59.0	18.8	13.8	24.2	25.2	NA	NA	NA	NA	8.0	12.5	8.5	14.5
Time steady state temperature maintained before changing ~ min.	NA	NA	70.0	66.0	69.0	70.0	NA	NA	45.0	55.0	46.0	46.0	NA	NA	NA	NA	NA	NA	NA	NA
Steady state temperature ~ ° C	+16.5	+18.0	+20.0	+16.0	22.0	+8.5	+3.0	+30.0	+28.0	+23.5	+20.0	+21.5	+25.0	+25.0	+16.0	+17.0-+20.0	+40.0	+39.0	+42.0	+40.0
Final temperature (end of run) ~ ° C	+25.0	+27.0	+29.0	+30.0	+26.0	+31.0	+8.5	+3.0	+30.0	+28.0	+23.5	+24.0	+25.0	+25.0	+16.0	+20.0	+40.0	+39.0	+42.0	+40.0
Time to achieve final temperature from ENCU on ~ min.	NA	NA	117.5	117.5	109.0	109.0	84.0	84.0	106.3	102.2	102.2	102.2	NA	NA	NA	NA	98.0	98.0	76.0	76.0

NOTES:
1. Data derived from figures III-1 through III-10, inclosure III.
2. Initial PAS air provided by external air source.
3. NA - data not available.

TABLE 3-5. BORESIGHT CHARACTERISTICS

Date/Temp	Mode	TV	FLIR	DVO	Remarks
13Nov/≈+70°F	Initial	-	-	-	Not completed. TADS prohibited from stow.
	Retention	-	-	-	Not completed. TADS prohibited from stow.
16Nov/+70°F	Initial	Yes	-	-	Intermittent laser. FLIR not completed due to loss of vector.
	Retention	Yes	-	-	
19Nov/+70°F	Initial	Yes	Yes	-	Did not have a good out-front target for DVO.
	Retention	-	-	-	
20Nov/+70°F	Initial	Yes	?	-	
	Retention	Yes	?	-	
23Nov/-25°F	Initial	Yes	Yes	Yes	Intermittent laser spot. DVO would not spiral.
	Retention	-	-	-	
24Nov/-25°F	Initial	-	-	-	Runs aborted.
	Retention	-	-	-	
25Nov/-25°F	Initial	Yes	Yes	Attempted	Intermittent laser spot. Lost FLIR vector. Hard to see FLIR cue. DVO would not spiral.
	Retention	Yes	Lost Vector	Yes	
27Nov/-25°F	Initial	-	-	-	FCC inop. BBC would not work weapon systems.
	Retention	-	-	-	

TABLE 3-5. BORESIGHT CHARACTERISTICS (Con't)

Date/Temp	Mode	TV	FLIR	DVO	Remarks
28Nov/+16°F	Initial	Yes	Yes	Yes	
	Retention	-	-	-	
1Dec/-50°F	Initial	-	-	-	TADS off.
	Retention	-	-	-	
2Dec/-50°F	Initial	-	-	-	Run aborted.
	Retention	-	-	-	
3Dec/-50°F	Initial	-	-	-	No FCC and TADS off.
	Retention	-	-	-	
4Dec/-50°F	Initial	-	-	-	TADS fail.
	Retention	-	-	-	
7Dec/+125°F	Initial	-	-	-	
	Retention	-	-	-	
8Dec/+125°F	Initial	-	-	-	TADS inop. EU-2 removed.
	Retention	-	-	-	
12Dec/+70°F	Initial	Yes	Yes	Yes	Could not see FLIR cue.
	Retention	Yes	Yes	Yes	
14Dec/+125°F	Initial	Yes	Yes	Yes	
	Retention	-	-	-	TADS failed.
15Dec/-25°F	Initial	-	Stuck in WFOV	Spiral one direction	TV camera inop.
	Retention	-	-	-	

TABLE 3-6. SYMBOL GENERATOR WARM-UP TIMES

DATE	TEMP	WARM-UP TIMES FOR USABLE SYMBOLOGY	REMARKS
16 Nov	+70°F	None	Instantaneous usable symbology
19 Nov	+70°F	None	Instantaneous usable symbology
20 Nov	+70°F	None	Instantaneous usable symbology
12 Nov	+70°F	None	Instantaneous usable symbology
28 Nov	+16°F	3 Min 18 Sec	Full cold soak
23 Nov	-25°F	No Data	Full cold soak - slow to warm-up, no times available
25 Nov	-25°F	21 Min 49 Sec	Full cold soak
27 Nov	-25°F	24 Min	Limited cold soak: 5 hours
15 Dec	-25°F	17 Min 13 Sec	Limited cold soak: 3 hours, 15 minutes
01 Dec	-50°F	No Data	Symbol generator heat soaked - FCC failed
03 Dec	-50°F	Would not provide usable symbology	Full cold soak
07 Dec	+125°F	None	Instantaneous usable symbology
08 Dec	+125°F	None	Instantaneous usable symbology
14 Dec	+125°F	None	Instantaneous usable symbology

TABLE 3-7. HARS ALIGNMENT

Date	Temp	Time to Align: Normal	Time to Align: Fast	Remarks
16 Nov	+70°F	NA	No Data	
19 Nov	+70°F	NA	No Data	
20 Nov	+70°F	NA	No Data	
12 Dec	+70°F	8 min 37 sec	Not Attempted	
28 Nov	+16°F	NA	1st Cycle 6 min 07 sec	
23 Nov	-25°F[1]	NA	Aligned No Data	HARS would not align on the first attempt (fast mode). After waiting 20-30 minutes, the HARS was recycled (fast mode).
25 Nov	-25°F[1]	NA	2nd Cycle 4 min 30 sec	HARS would not align on the first attempt (fast mode). After waiting for 30 minutes the HARS was recycled (fast mode).
15 Dec	-25°F[1]	Would not Align	2nd Cycle 4 min 23 sec	HARS would not align on the first attempt normal mode). After 30 minutes the HARS was recycled (fast mode).
15 Dec	-25°F	NA	3rd Cycle 7 min 29 sec	HARS headings went oscillatory. Another alignment (fast mode) was completed. Headings remained unreliable.
1 Dec	-50°F	Would not Align	Would not Align	

TABLE 3-7. HARS ALIGNMENT (Con't)

Date	Temp	Time to Align: Normal	Time to Align: Fast	Remarks
3 Dec	-50°F	Would not Align	Would not Align	
4 Dec	-50°F	Would not Align	Would not Align	HARS preheated for 40 minutes w/Herman Nelson.
7 Dec	+125°F	NA	5 min 07 sec	
8 Dec	+125°F	6 min 27 sec	NA	
14 Dec	+125°F	NA	5 min 48 sec	

NOTES:
1. All alignments at -25°F required two cycled.
2. On normal alignment, only one normal alignment cycle was tried before going to fast.
3. The 1st HARS was replaced after the 4 Dec test run at -50°F.

Table 3-8. AWS Gun/Feed System Physical Differences

AV03 (Climatic Hangar)	AV06 (Latest Configuration)
1. Magazine - flat pac.	1. Magazine - 12 pac.
2. Standard armament aft flex chutes.	2. Noblas aft flex chutes diff # of segments.
3. Tensioners - 1 each main rod - 2 each small guide rods.	3. 3 each main extension rods bronze bushings.
4. Extension springs - total 80 pounds per tensioner.	4. Compression springs - 3 each @ 30 pounds each per spring per inch, i.e., for 3 inch movement, 270 pounds total per tensioner.
5. Aft elbows - smaller diameter, uses rollers.	5. Greater diameter because of sprockets that pick up carriers.
6. Fwd flex chute - differ in amount of segments, i.e., 33 each with flexible fingers @ gun end.	6. 26 each segments with solid fingers @ gun end.
7. Transfer housing - 4 each small lug gun end attach points. smaller tear drops (Hughes-type transfer housing).	7. 2 each large lug gun end attach points used with lg bolts (2 each), large strap-type tear drops. Housing used to upload through feed cover door with loader/downloader). (W.D.C. type transfer housing).
8. Gun unmodified for loader/downloader use. Must load @ aft rt, tensioner. 2 each index dr. lock pins to hold index dr. to gun receiver.	Gun modified for loader/downloader - clutch housing and RD guide base plate machined to accommodate uploading thru gun. Gun has 3 ea thru bolts instead of lock pins, to accept loader/downloader.

Table 3-9. Area Weapon System Operation

Date	Temp	Rounds Cycled	Gun Position
13 Nov	+70° F	12	Fix Fwd
19 Nov	+70° F	15	Fix Fwd
20 Nov	+70° F	7	Fix Fwd
25 Nov	-25° F	25	45 L, 45 Dn
28 Nov	+10° F	41	45 L, 45 Dn
4 Dec	-50° F	141	Fix Fwd
10 Dec	70° F	14	45 L, 45 Dn
12 Dec	70° F	18	45 L, 45 Dn
15 Dec	-25° F	205	45 L, 45 Dn
	Total	478 Rounds Cycled	

NOTE: 1. Unable to cycle gun at +125° F due to aircraft mission equipment problems.

2. Gun positions are only approximate.

Table 3-10. YAH-64 Environmental Survey (-25°F)

Crew Station: Pilot

Outside Air Temp: -25°F

Environmental Control Unit: Full Heat

AIRFLOW (FPM) /TEMP (degrees F)

FLIGHT MODE	LOCATION				
	LEFT PEDAL	RIGHT PEDAL	CYCLIC GRIP	LEFT PANEL DUCT	RIGHT PANEL DUCT
Rotor Stopped ENCU on	50 FPM/ 59°	50 FPM/ 55.4°	62.6°	131°	123.8°
100% Rotor RPM Flat Pitch (No Torque)	250 FPM	350 FPM	50 FPM		
Hover 50% Torque	1200 FPM/ 21.2°	1000 FPM/ 21.2°	100 FPM/ 35.6°		
Takeoff 64% Torque	900 FPM/ 19.4°	1100 FPM/ 21.2°	70FPM/ 32°		
Climb/Cruise 100% Torque	1500 FPM	2000 FPM	100 FPM		
Single Engine 70%	700 FPM/ 17.6°	700 FPM/ 21.2°	100 FPM/ 42.8°		

Table 3-11. YAH-64 Environmental Survey (-50°F)

Crew Station: Pilot

Outside Air Temp: -50°F

Environmental Control Unit: Full Heat

AIRFLOW (FPM) /TEMP (degrees F)

FLIGHT MODE	LOCATION				
	LEFT PEDAL	RIGHT PEDAL	CYCLIC GRIP	LEFT PANEL DUCT	RIGHT PANEL DUCT
Rotor Stopped ENCU on	50 FPM/ 28.4°	50 FPM/ 23°			
100% Rotor RPM Flat Pitch (No Torque)	700 FPM/ -9.4°	1500 FPM/ -7.6°	100 FPM		
Hover 47% Torque	900 FPM/ -14.8°	1200 FPM/ -5.8°	15.8°		
Climb 100% Torque		-14.8°	15.8°	134.6°	127.4°
Cruise 34° Torque	-14.8°	-2.2°	19.4°	134.6°	127.4°

Table 3-12. YAH-64 Environmental Survey, Pilot Station (+125^{o}F)

Crew Station: Pilot

Outside Air Temp: 125°F

Environmental Control Unit: Full cool

FLIGHT MODE	AIRFLOW (FPM) /TEMP (degrees F) LOCATION				
	LEFT PEDAL	RIGHT PEDAL	CYCLIC GRIP	LEFT PANEL DUCT	RIGHT PANEL DUCT
100% Rotor RPM Flat Pitch (No Torque)	100 FPM/ 123.8°	200 FPM/ 123.8°	50 FPM/ 111.2°	73.4°	77°
Hover 54% Torque	900 FPM/ 122°	750 FPM/ 120.2°	118°	75.2°	75.2°
Takeoff 70% Torque	900 FPM/ 118.4°	1000 FPM/ 120.2°	200 FPM/ 113°		
Climb 80% Torque	1000 FPM/ 122°	1000 FPM/ 123.8°	200 FPM/ 113°	75.2°	80.6°
Power Descent 37% Torque	700 FPM	700 FPM			

Table 3-13. YAH-64 Environmental Survey, CPG Station (+125°F)

Crew Station: CPG

Outside Air Temp: 125°F

Environmental Control Unit: Full cool

AIRFLOW (FPM)/TEMP (degrees F)

LEFT FLOOR DUCT	RIGHT FLOOR DUCT	RIGHT AFT DUCT	LEFT PANEL DUCT	RIGHT PANEL DUCT
5500 FPM/ 86°	4500 FPM/ 89.6°	4800 FPM/ 86°	100 FPM/ 89.6°	250 FPM/ 96.8°

Figure 3-1
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (+70° F)

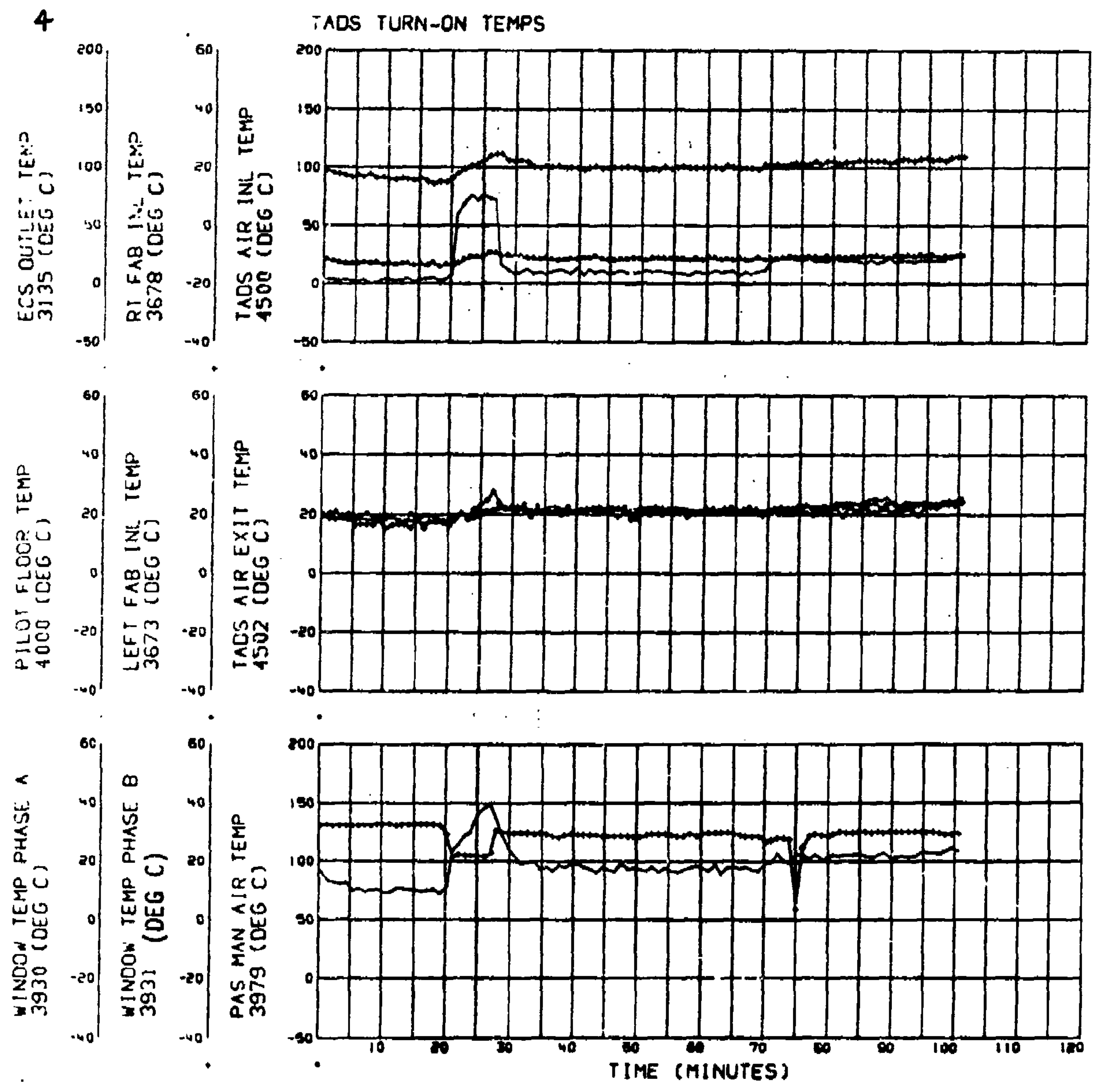


Figure 3-1 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (+70° F)

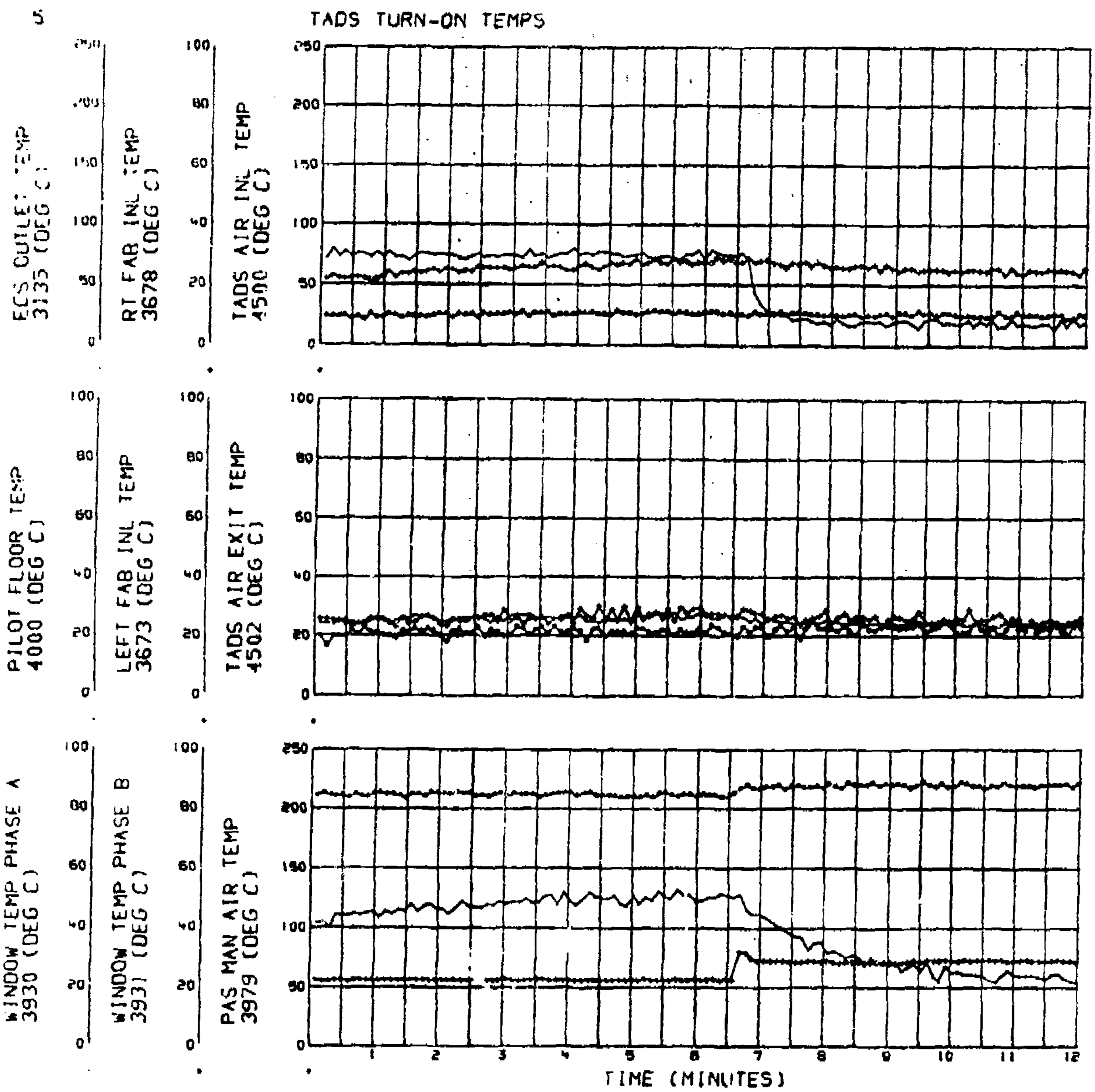


Figure 3-1 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (+70° F)

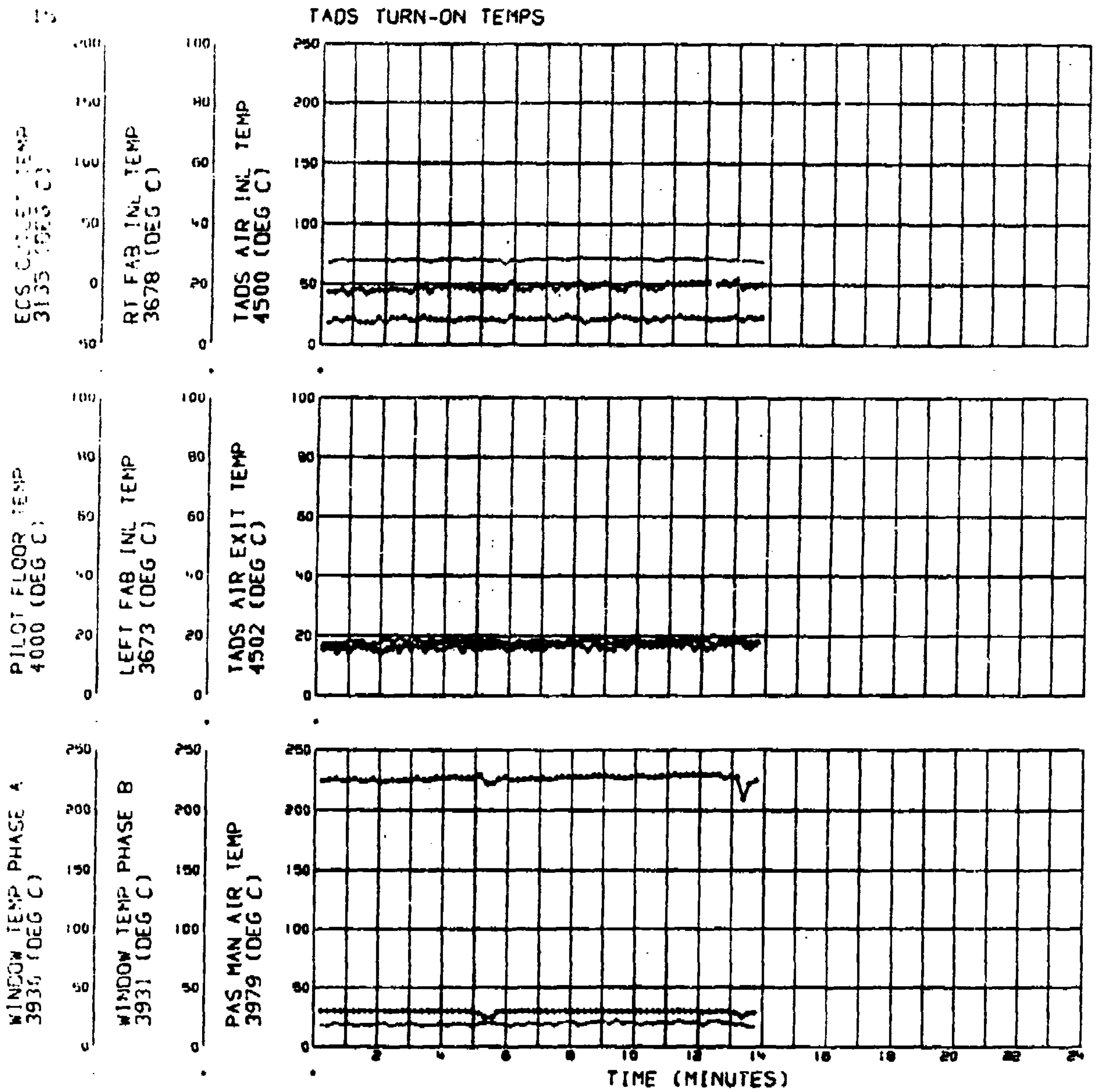


Figure 3-2
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (-25° F)

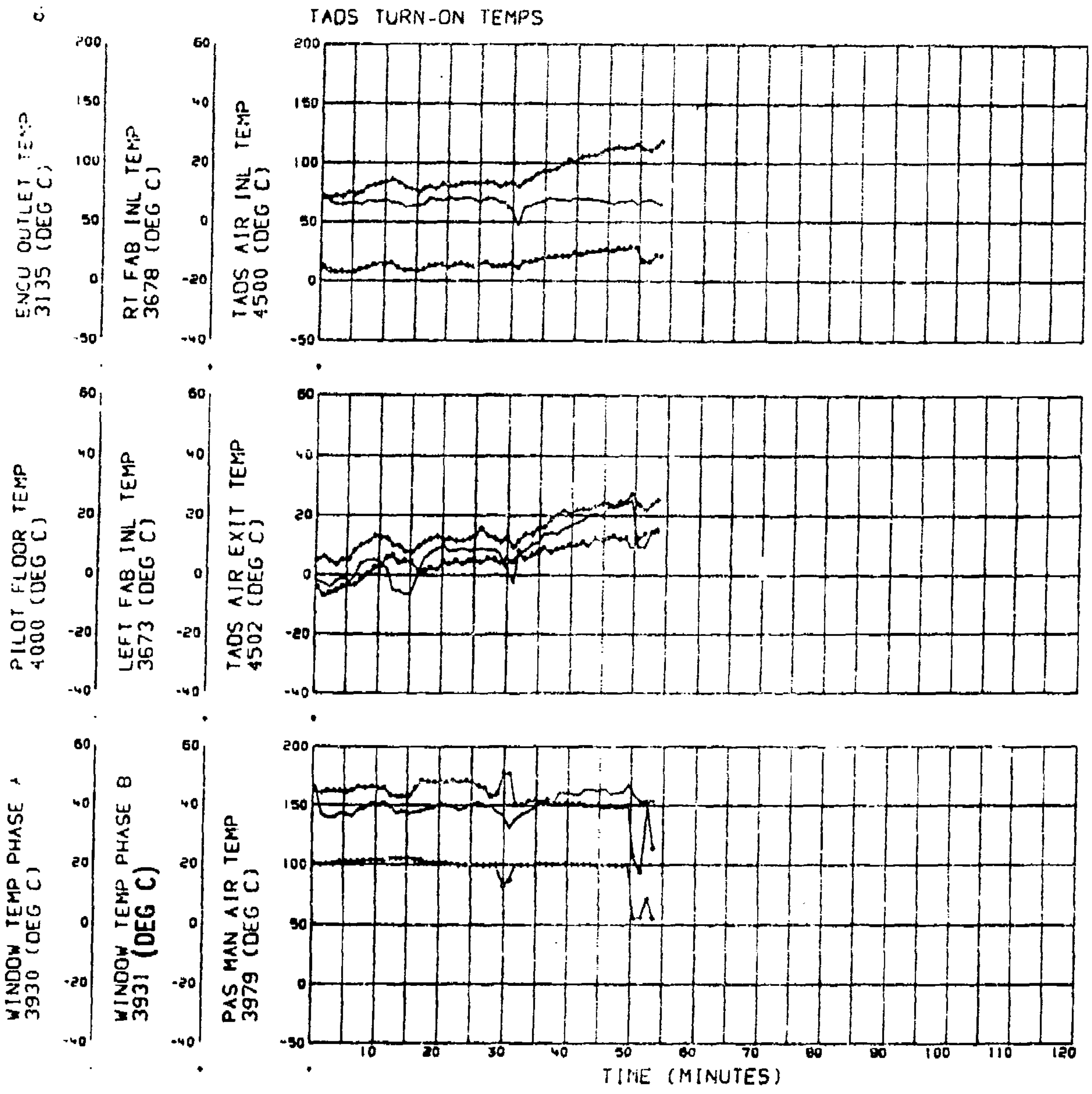


Figure 3-2 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (-25° F)

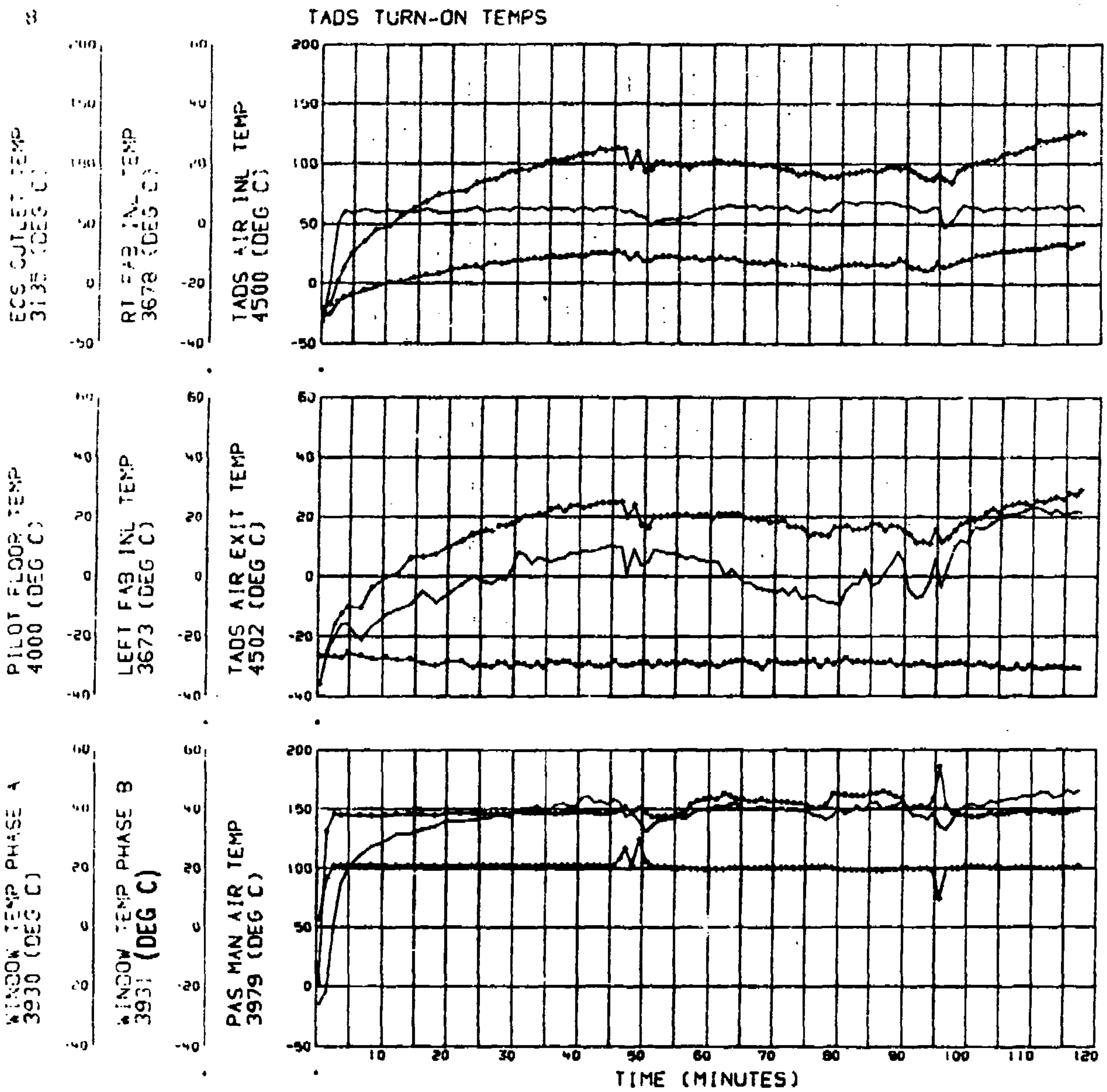


Figure 3-2 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (-25° F)

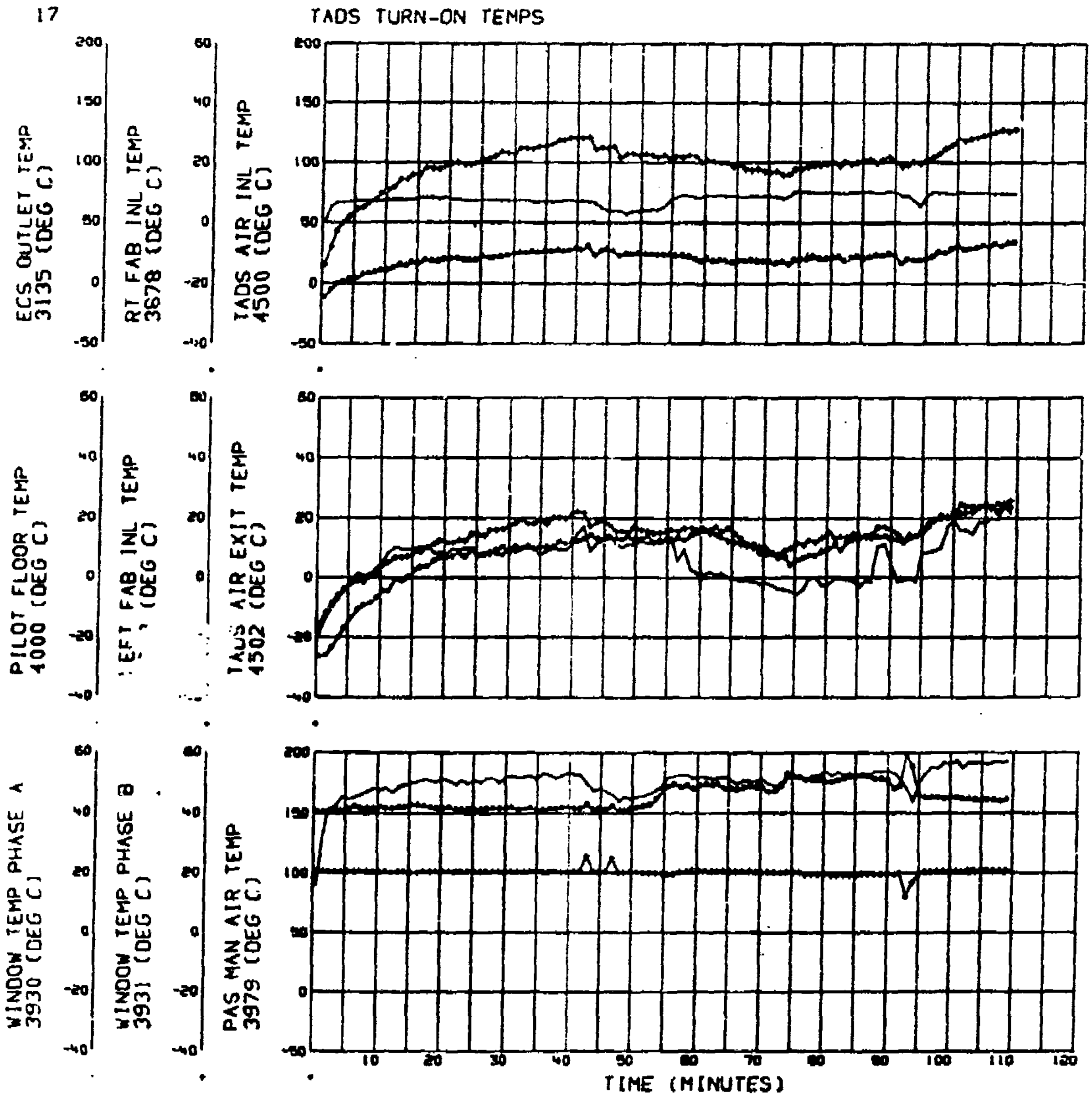


Figure 3-3
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (-50° F)

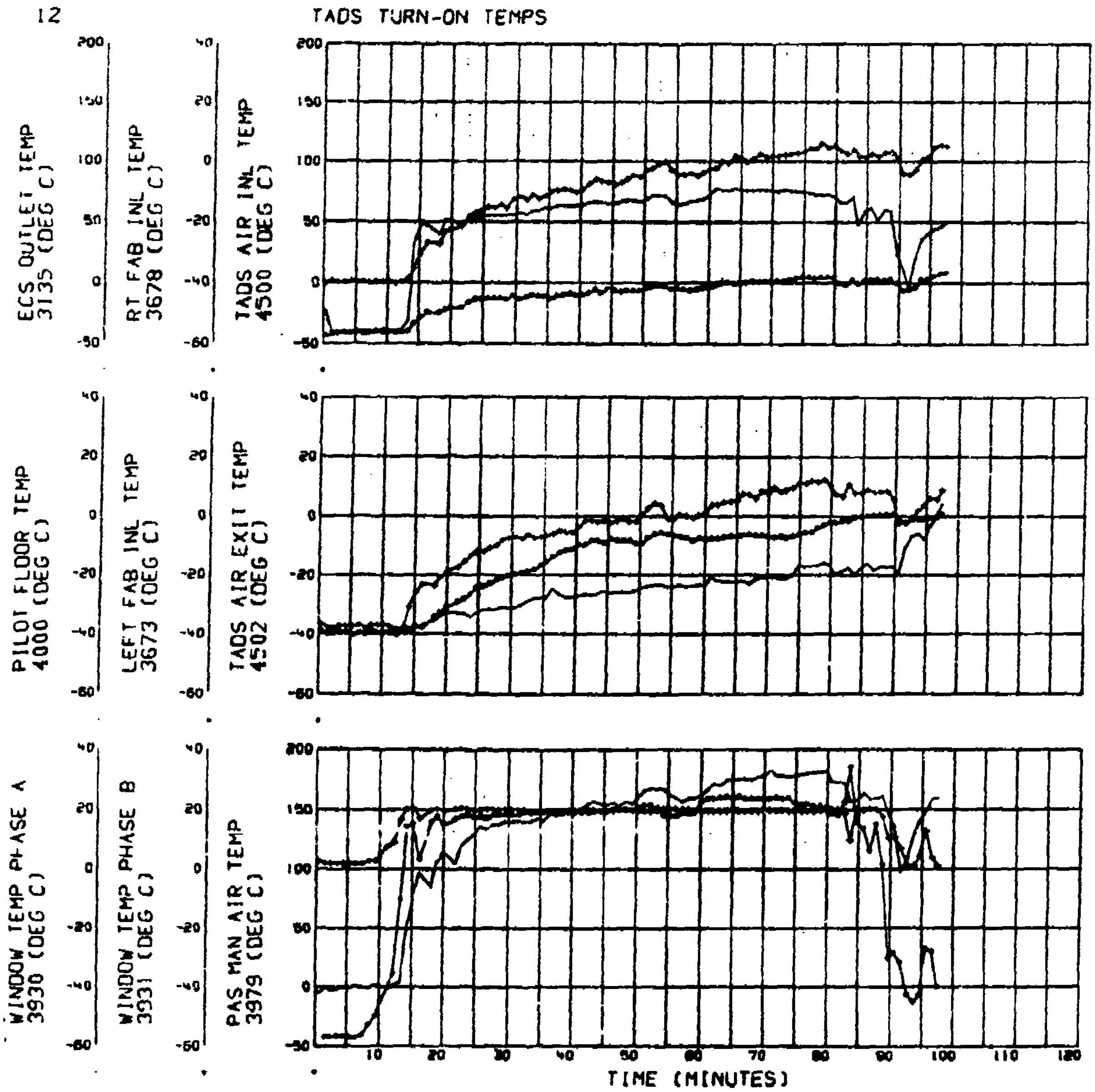


Figure 3-3 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (-50° F)

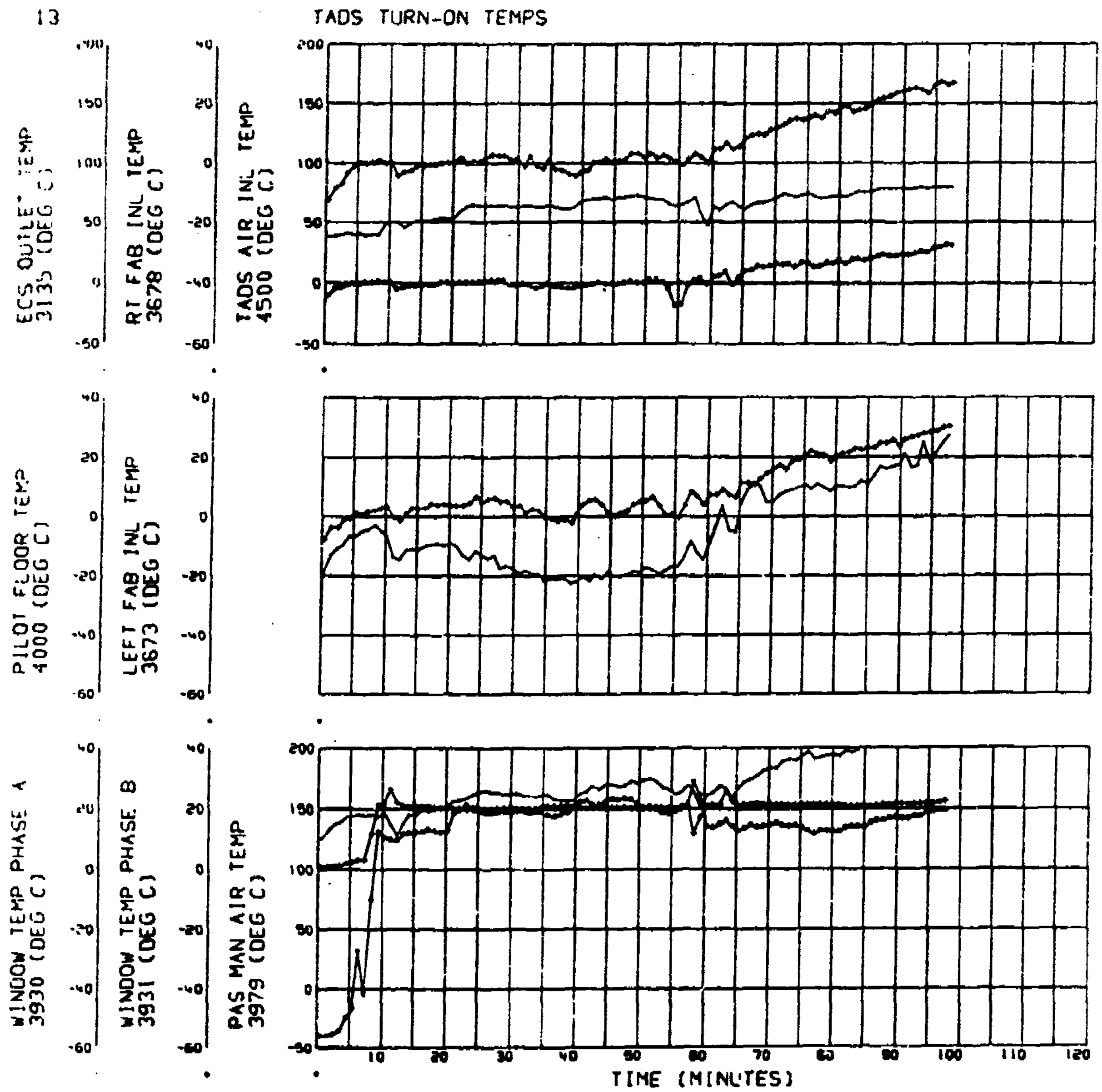


Figure 3-4
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (+125° F)

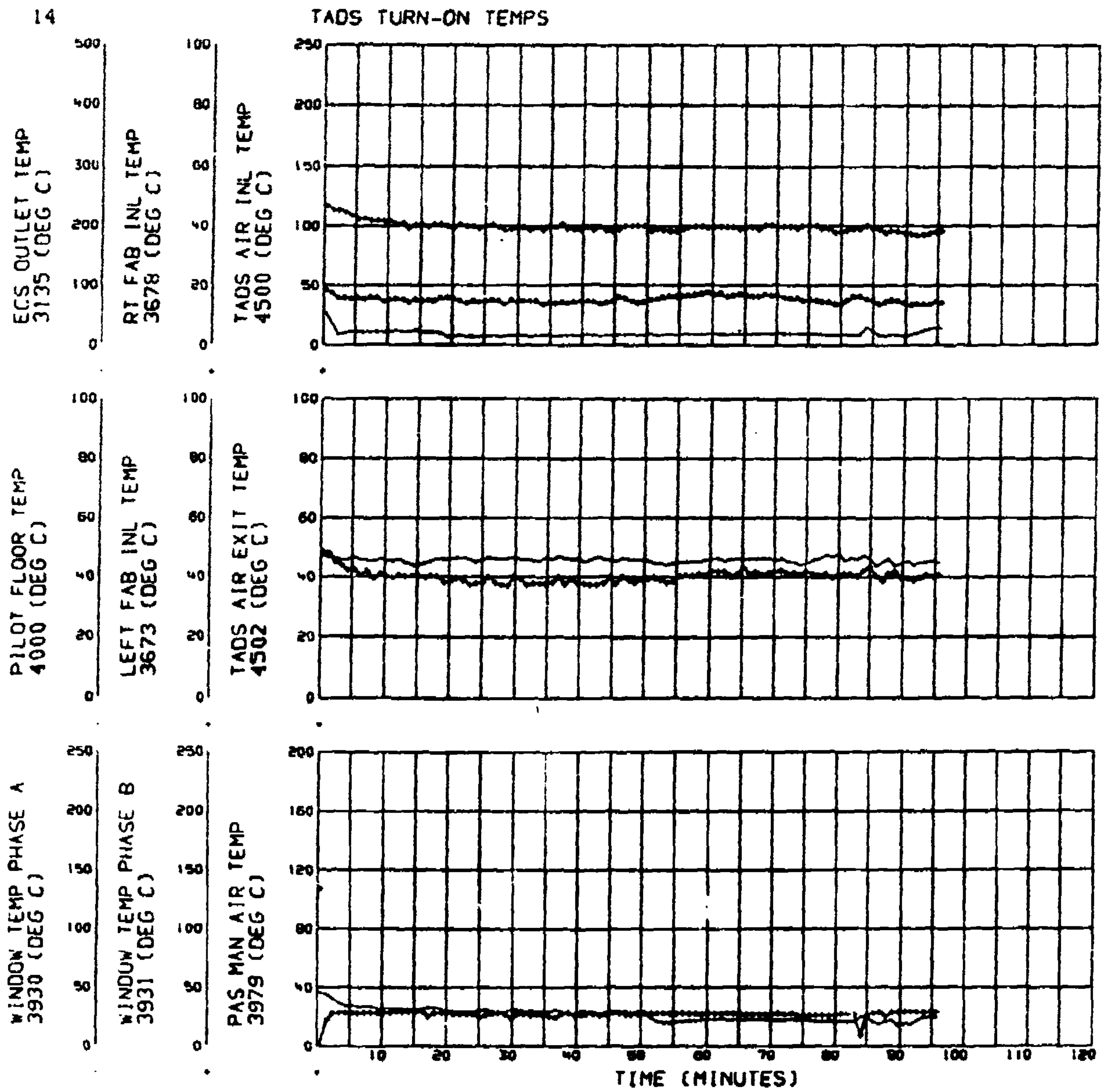
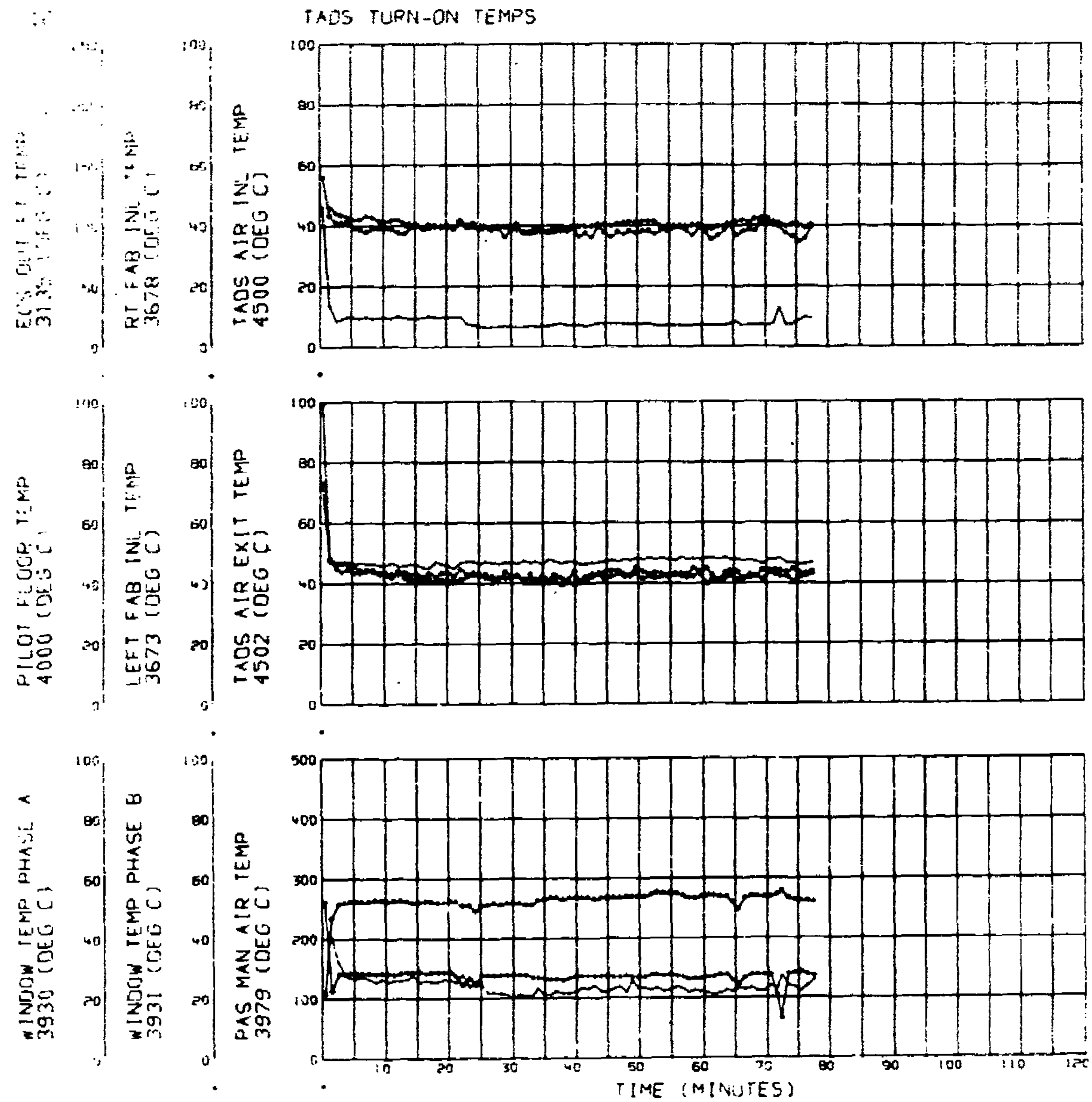


Figure 3-4 (Con't)
Mission Equipment Air Temperature Survey
YAH-64 USA SN 74-22249
Climatic Laboratory Temperature (+125° F)



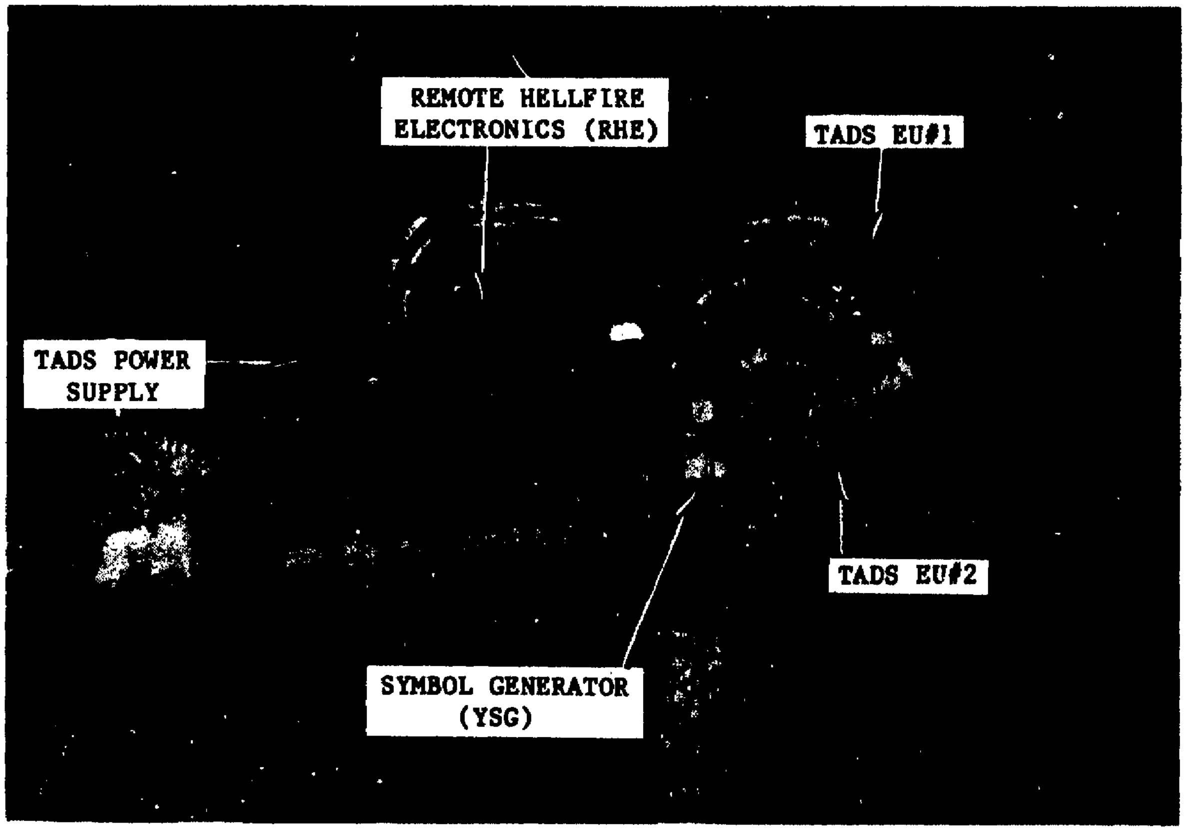


Figure 3-5. Right Forward Avionics Bay

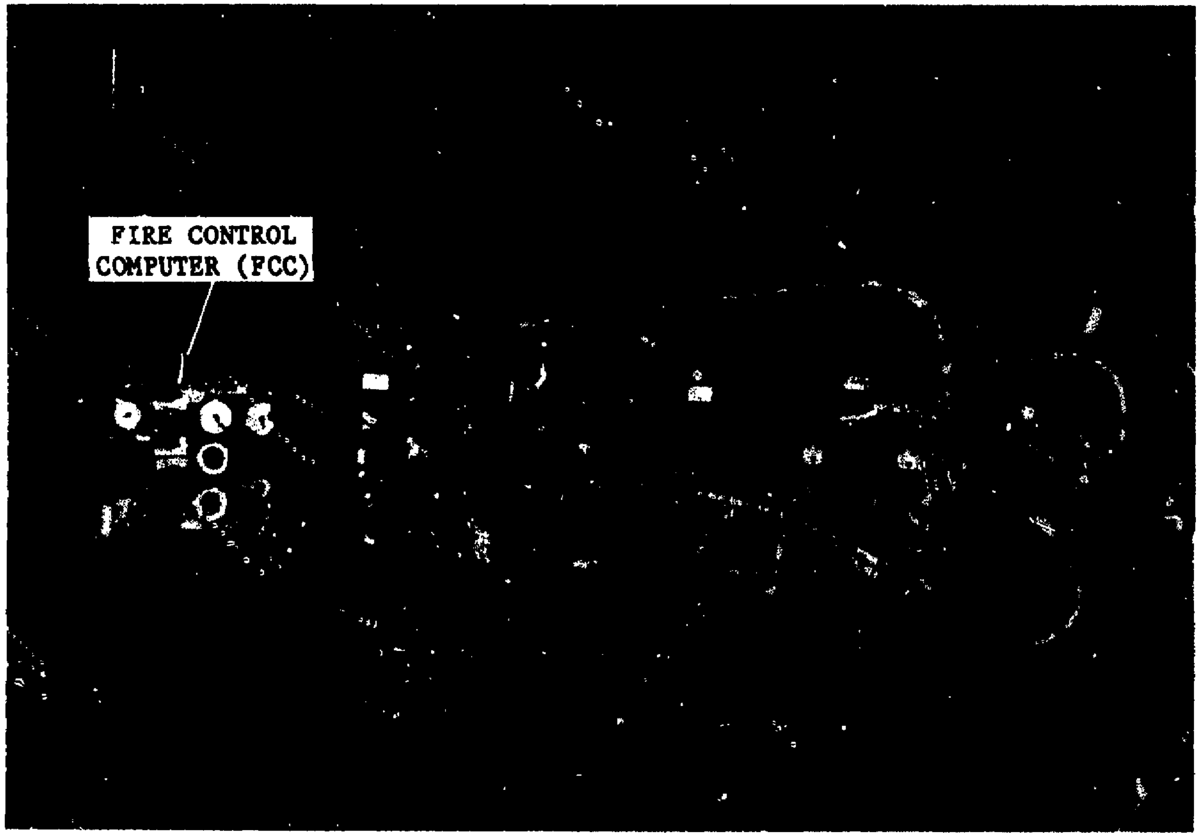
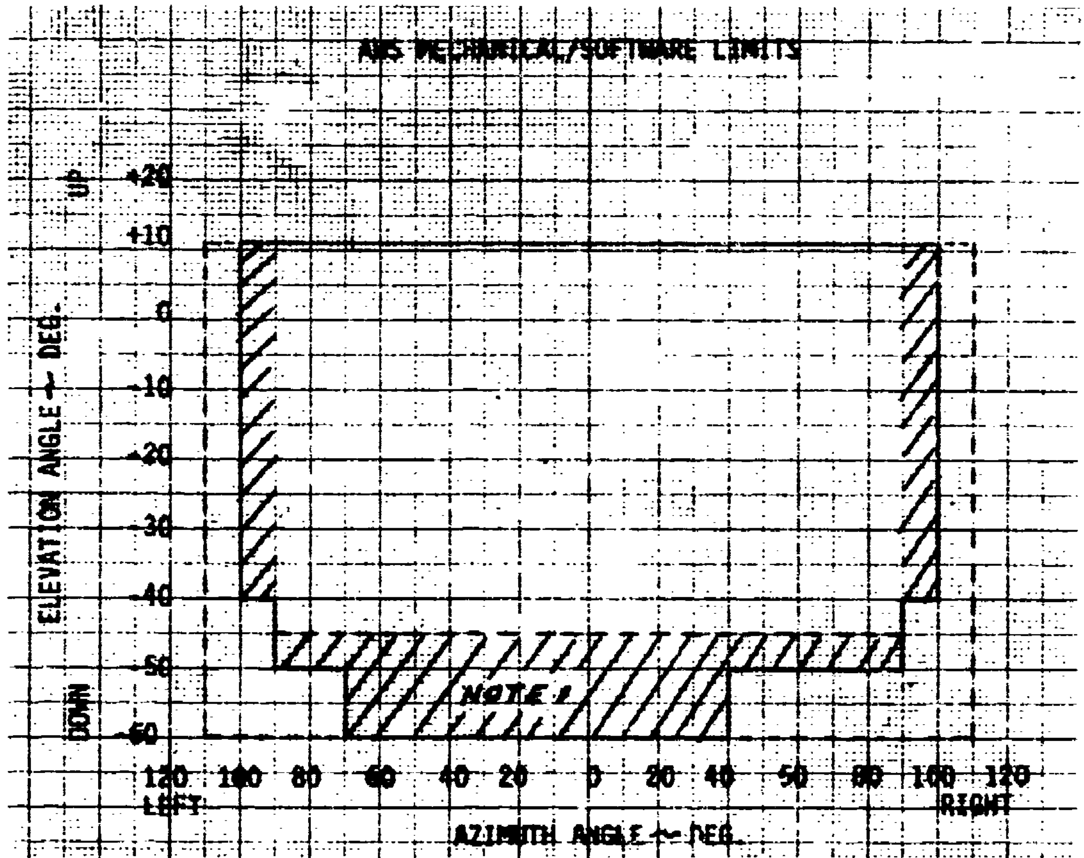


Figure 3-6. Left Forward Avionics Bay



NOTES:

1. Cross-hatched area denotes software fire inhibit (not a mechanical limit).

2. Gun Limits established to represent actual TADS viewing conditions per Hughes Ordnance Division.

3. Hard lines indicate recommended gun limits (corresponding to TADS limits).

4. Dashed lines represent physical gun stops.

Figure 3-7. AWS Mechanical/Software Limits

Figure 3-8. Tail Rotor Pedal Slots

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